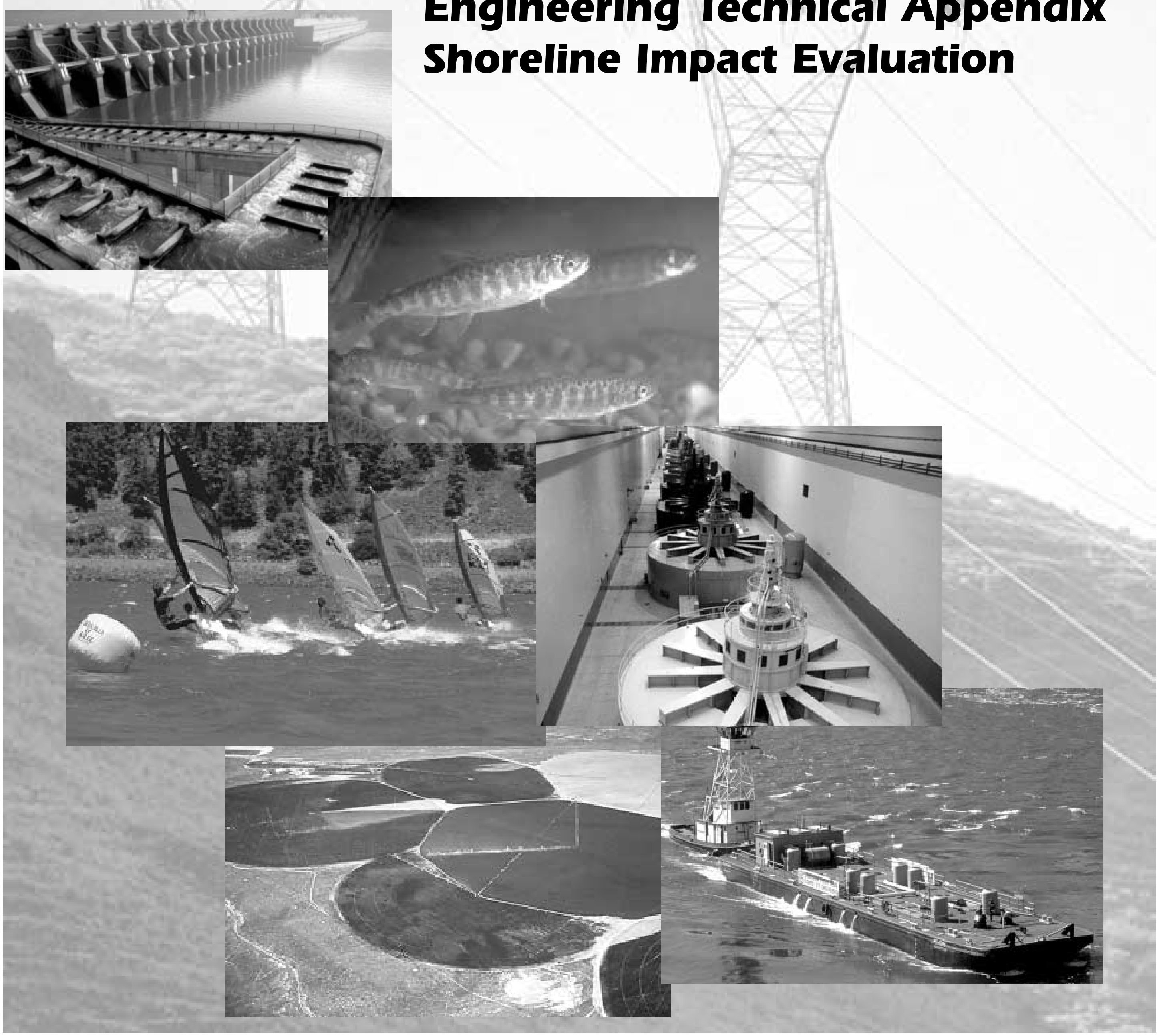
US Army Corps of Engineers®
Portland District

Salmon Recovery through John Day Reservoir

John Day Drawdown Phase I Study

Engineering Technical Appendix Shoreline Impact Evaluation



September 2000

JOHN DAY DRAWDOWN STUDY

SHORELINE IMPACT EVALUATION

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August 4, 1999

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1. INTRODUCTION

1.1 General

In 1991, Snake River wild sockeye, spring, summer, and fall chinook salmon were proposed for endangered or threatened status under provisions of the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS). In its Biological Opinion (BiOp) on operation of the Federal Columbia River Power System, Reasonable and Prudent Action (RPA) #5, NMFS recommended that the Corps of Engineers investigate the feasibility of lowering the John Day reservoir to spillway crest.

Natural resource agencies believe that lowering the John Day reservoir may decrease juvenile salmonid travel times and create a more natural shoreline and benthic community structure, similar to the unimpounded reach of the Columbia River. The main stem spawning populations of fall chinook salmon appear to be healthy and productive in that reach. It has been proposed that drawdown of the 76-mile John Day reservoir may provide substantial improvements in migration and rearing conditions for juveniles by increasing river velocity, reducing water temperature and dissolved gas, and restoring spawning habitat. Drawdown of John Day pool may improve spawning conditions for adult fall chinook by restoring spawning habitat and the natural flow regimes needed for successful incubation and emergence.

There are two regional goals for a drawdown of John Day reservoir, as identified in NMFS' draft Recovery Plan for Snake River salmon, the Tribal Restoration Plan, and the Northwest Power Planning Council's Fish and Wildlife Programs. Those goals include: (1) improve migration and rearing conditions for juvenile spring, summer and fall chinook, sockeye, and steelhead, (2) reduce water temperature and total dissolved gas to comply with Clean Water Act criteria and standards, and (3) improve spawning conditions of fall chinook salmon.

In response to direction provided in the Energy and Water Development Appropriation Bill, 1998, the Corps of Engineers is studying the potential drawdown of the John Day reservoir to spillway crest and natural river conditions. Normal full pool elevation is 265 feet above National Geodetic Vertical Datum (NGVD); operation at spillway crest would result in a pool elevation that will vary from about 217 to 230 feet NGVD; and natural river elevation would be about 170 feet NGVD. The Corps' initial analysis is a reconnaissance-level study evaluating biological, social and economic benefits and costs of the two proposed alternatives, that identifies the potential physical impacts of drawdown. If justified, a feasibility-level evaluation of all the benefits, costs and physical impacts associated with a range of reasonable drawdown alternatives will be performed.

1.2 Goals and Objectives

For both drawdown scenarios, structural impacts may occur to both culverts and bridges along the John Day Pool. There are more than 20 bridges, and hundreds of culverts, which border the reservoir. Due to the much lower pool elevation, scouring may occur to road and railroad embankments located below culvert outfalls. There is also the potential for failure of bridge piers due to scour.

The objectives of the shoreline impact analysis are to first identify what bridges and culverts could potentially be impacted by drawdown, then determine the type and extent of impact, and finally develop modification measures. A map of the reservoir and its key features is shown in Plates 1-1 to 1-5.

1.3 Organization of Report

In addition to this introductory section, the study report is comprised of six additional sections:

Chapter 2. DATA, summarizes the sources and type of information relevant to the study.

Chapter 3. FIELD SURVEY, describes the field survey and the information obtained from it.

Chapter 4. ANALYSIS OF IMPACTS, presents the approach and methods of evaluating the impacts to bridges and culvert.

Chapter 5. MODIFICATION MEASURES, presents the various solutions to mitigate the bridges and culverts, and the amount of material required.

Chapter 6. SUMMARY, describes the overall conclusions and recommendations of the shoreline impact evaluation.

Chapter 7. REFERENCES, identifies the sources of information utilized in preparing the study.

2. DATA

To develop an inventory of bridges and culverts, the roads and railroads that could be affected by drawdown of the reservoir were first determined. On the Oregon side, Interstate 84, Stage Highway 730, and the Union Pacific Railroad (UP) line all border the reservoir. In Washington, State Highway 14 and the Burlington Northern & Santa Fe Railroad (BNSF) line border the reservoir. There are also two Interstate 82 bridges which cross the reservoir near McNary Dam. We were able to obtain the track profiles for both railways, and the bridge logs from the Oregon and Washington Departments of Transportation. The inventory (Appendix A) was compiled from the track profiles and bridge logs. Bridge plans for nearly all the bridges were also acquired from the departments of transportation, and railroads.

2.1 Washington DOT Structures

Washington State Route 14 parallels the John Day Reservoir on the northern side. In some areas, especially in the lower pool, the highway is near the river. In other areas the highway is set back from the river, and several hundred feet higher than the pool elevation. The Washington Department of Transportation (WSDOT) Bridge List only shows five bridges and one set of culverts for the reach of highway along the reservoir. WSDOT furnished bridge plans for the bridges at Rock Creek, Wood Gulch, Alder Creek, Dead Canyon Creek, and Glade Creek.

2.2 Burlington Northern & Santa Fe Railroad

The Burlington Northern & Santa Fe (BNSF) Railway line also borders the reservoir on the northern side. The rail line is sandwiched between the reservoir and SR-14. In many locations the railway embankment is right against reservoir. Because of its proximity to the reservoir, the impacts to the rail line would be much greater than impacts to SR-14. The track profile for the BNSF rail line is by far the most comprehensive of all the bridge lists and track profiles. It lists more than 300 culverts and bridges between John Day and McNary Dams. Bridge plans for six bridges were also obtained.

2.3 Oregon DOT Structures

Interstate 84 (I-84) parallels the south side of the John Day Reservoir on the Oregon side. This four-lane interstate freeway follows the shoreline from John Day Dam to approximately the City of Boardman, before veering south and away from the reservoir. The Oregon Department of Transportation (ODOT) bridge log lists 17 bridges or culverts along the reservoir. Plans for the bridges at the John Day River, Arlington, and Willow Creek, were obtained from ODOT.

Oregon State Highway 730 only parallels a small portion of the reservoir from the City of Irrigon to the City of Umatilla. The ODOT Bridge Log lists two bridges and one culvert for the highway. Bridge plans for the Umatilla River Bridge were also obtained from ODOT.

Interstate 82 (I-82) does not parallel the John Day Reservoir at any point, however it does cross the reservoir about a mile and a half downstream of McNary Dam. The crossing consists of two two-lane bridges, an original one, and then a newer one that was constructed when the highway was upgraded to an interstate. Bridge plans for the original bridge were provided by ODOT.

2.4 Union Pacific Railroad

Similar to the Washington side of the reservoir, the Union Pacific Railroad (UP) line is sandwiched between I-84 and the reservoir, and would be more exposed to the impacts of drawdown. The UP line also breaks away from the reservoir at the City of Boardman. The UP track profile lists 34 bridges and culverts and seems to be far less comprehensive than the BNSF track profile. UP also provided plans for the bridges at the John Day River, Arlington, and Willow Creek.

3. FIELD SURVEY

Using the bridge and culvert inventory as a guide, a weeklong field reconnaissance of all of the bridges and many of the culverts was performed. From May 10, 1999 to May 13, 1999, all the bridges and selected culverts were visited, examined, and photographed. The main objective of the field reconnaissance was to familiarize team members with pertinent study sites, determine if the culverts and bridges were in the backwater of the reservoir, and assess the potential impacts that could result from drawdown of the reservoir. Other general notes about the structures were also recorded. The field reconnaissance began on the Oregon side of the reservoir at John Day Dam, progressed upstream to McNary Dam, and then back downstream to John Day Dam on the Washington side of the reservoir.

3.1 Data Sheet

For the field survey, data sheets were filled out for every bridge and culvert visited, and at least one photograph was taken. There were separate data sheets for bridges and culverts. Examples of bridge and culvert data sheets are shown in Appendix B.

3.2 Condition of Bridges

A total of 22 bridges were visited. 18 of the bridges were within the backwater of the existing reservoir, while the four others were very near the backwater. The site investigation showed that nearly all the bridges could be impacted by drawdown, depending on the foundation characteristics.

3.3 Condition of Culverts

Of the more than 300 culverts in the inventory, 57 were visited. Most of the culverts investigated were the major (larger) ones with contributing drainage areas of over one square mile. A few of the smaller culverts were also investigated. Many of the culverts spilled directly out onto the riprapped railroad embankments. These culverts would be the most critical, as they could suffer the greatest impact from drawdown. Some of the larger culverts (generally those larger than five feet in diameter) had grouted riprap or concrete aprons at the outlet, while the small ones usually did not. Generally, the culverts at the embankments were three to four feet above the water surface. The majority of the culverts were corrugated metal pipes of varying sizes.

4. ANALYSIS OF IMPACTS

4.1 Approach

To analyze the impacts of drawdown on bridges, each bridge was individually evaluated. Culverts were screened into three categories because of the large number and limited data. Those categories include: (1) those that spill directly onto the embankments bordering the reservoir, (2) those that are significantly away from the reservoir, or outlet onto a delta that is sufficiently large and vegetated, or (3) those that would leave ponded water trapped upstream if the reservoir is drawn down.

4.2 Evaluation of Bridges

Several criteria were assessed for each bridge. First, there is the possibility for drawdown to create scour that could potentially undermine the piers. Second, there has to be adequate fish passage after drawdown for tributaries that support migrating fish populations. Those tributaries are the John Day River, Willow Creek, Umatilla River, Wood Gulch, and Rock Creek. Third, several tributaries (John Day River, Willow Creek, Umatilla River, and Rock Creek) may require dredging to achieve a stable channel for sediment. This dredging could also undermine the bridge piers, or make them vulnerable to scour.

- **John Day River I-84 Bridge.** The I-84 Bridge over the John Day River is within the backwater of the reservoir. Drawdown of the reservoir would change the channel hydraulics from a pool to a free flowing river condition. It's worthy to note that a previous bridge over the John Day River at the same location failed during the Flood of 1964, due to scour undermining Pier 3. The John Day Reservoir was not full in 1964, and the river was free flowing. The current bridge has both piers with footings, and piers with piles. The bridge plans show that all of the footings and piles are on bedrock. Drawdown will not block fish passage to the river, and no dredging will be required. No modification is required.

- **John Day River UP Railroad Bridge.** The UP Bridge over the John Day River is immediately downstream of the I-84 Bridge. All of the pier footings are set in rock, except the center pier, which has piles. The top of the pile cap elevation at the center pier is 162 feet NGVD, and the bottom elevation is 145 feet NGVD. The elevations of the pile tips are unknown. The bridge plans indicate the bridge was built prior to the 1964 Flood. Since this bridge withstood the 1964 Flood, it is assumed that no modification is required.

- **I-84 Arlington Viaduct.** The I-84 Arlington Viaduct crosses a small marina and park at the mouth China Creek. The foundation for the bridge is set in rock at all the piers except Pier 1. However, Pier 1 is well outside of the channel. No modification is required.

- **Alkali Canyon UP Railroad Bridge.** The UP Bridge over Alkali Canyon is just downstream of the I-84 Arlington Viaduct. The UP Bridge is much shorter than the viaduct. The footings for the bridge are all set on rock. No modification is required.

- **Willow Creek I-84 Eastbound Bridge.** There are a group of three bridges at the mouth of Willow Creek, I-84 eastbound, I-84 westbound, and a UP Bridge. The I-84 Eastbound Bridge is the furthest upstream. The bottom of footing elevation is 199 feet NGVD for both of the piers that are in the channel. The current thalweg elevation is 230 feet NGVD. However, the channel has to be dredged approximately 20 feet deeper with a 2:1 channel sideslope, to achieve adequate fish passage and a stable channel. The bridge is just long enough to do this, and the footings are just deep enough. Therefore, no modification is required.

- **Willow Creek I-84 Westbound Bridge.** The I-84 Westbound Bridge over Willow Creek is between the eastbound bridge and UP Bridge. The bottom of footing elevation is 195 feet NGVD for both piers that are in the channel. The channel thalweg elevation is 230 feet NGVD. The bridge is approximately the same size and has the exact same dredging circumstances as the eastbound bridge. The bridge is just adequate to accommodate 20 feet of dredging. No modification is required.

- **Willow Creek UP Railroad Bridge.** The UP Bridge over Willow Creek is the furthest downstream and is much longer than the I-84 bridges. The bridge has four piers supported by piles. The estimated pile tip elevations for the center piers are 145 feet NGVD, with a bottom of pile cap elevation of 196 feet NGVD. This bridge is also adequate to accommodate 20 feet of dredging. No modification is required.

- **Umatilla River Highway 730 Bridge.** The Highway 730 Bridge over the Umatilla River is supported by footings, and they are all set in rock. Therefore, no modification is required.

- **Umatilla River Footbridge.** A pedestrian bridge is located on the Umatilla River within the City of Umatilla, upstream of the Highway 730 bridge. The bridge is 195 feet long and only 10 feet wide. It has two piers in the channel, with an unknown foundation. Since most of the Umatilla River is bedrock controlled, and the Highway 730 Bridge is set on bedrock, it is assumed that the footbridge piers are also on bedrock. No modification is required.

- **Columbia River I-82 Bridges.** Two parallel I-82 bridges cross the Columbia River only a mile and a half downstream of McNary Dam. Since the bridges are at the very upstream end of the reservoir, drawdown will change the river hydraulics very little. Therefore no modification is required.

- **Rock Creek Highway 14 Bridge.** The Highway 14 Bridge over Rock Creek is a clear span bridge with the abutments set in bedrock. Fish passage on Rock Creek is a concern. The thalweg is a bedrock sill, and the elevation is 245 feet NGVD, which is well above the reservoir water surface elevation for both drawdown scenarios. This would then become a blockage to fish passage that could not be dredged. Therefore **modification is required** at the Highway 14 Bridge over Rock Creek.

- **Rock Creek BNSF Railroad Bridge.** The BNSF Bridge over Rock Creek is very similar to the Highway 14 bridge. It is a clear span with the abutments set in bedrock, and has a bedrock sill, which would block fish passage. **Modification is required** at the BNSF Bridge over Rock Creek.

- **Chapman Creek BNSF Railroad Bridge.** The BNSF Bridge over Chapman Creek has abutment piles and a pier footing that is set on rock. No modification is required.

- **Wood Creek Highway 14 Bridge.** The Highway 14 Bridge over Wood Creek is just outside of the reservoir backwater. Hydraulic conditions would not change after drawdown, and a head cut up to the bridge appears unlikely due to the great distance from the bridge to the main channel of the Columbia. No modification is required.

- **Wood Creek BNSF Railroad Bridge.** The BNSF Bridge over Wood Creek is downstream of the Highway 14 Bridge, and in the reservoir backwater. However, the bridge is still a long distance from the main channel of the Columbia. The bridge is supported by spread footings founded on bedrock. No modification is required.

- **Alder Creek Highway 14 Bridge.** The Highway 14 Bridge over Alder Creek is supported by footings that are below the rock line. No modification is required.

- **Alder Creek BNSF Railroad Bridge.** The BNSF Bridge over Alder Creek is immediately downstream of the Highway 14 Bridge. The bridge is also supported by spread footings founded in bedrock. No modification is required.

- **Dead Canyon Highway 14 Bridge.** The Highway 14 Bridge over Dead Canyon is outside of the backwater, and a long distance from the main channel of the Columbia. The possibility of a head cut to the bridge after drawdown is very unlikely. No modification is required.

- **Dead Canyon BNSF Railroad Bridge.** The BNSF Bridge over Dead Canyon in immediately downstream of the Highway 14 Bridge. It also is outside of the reservoir backwater, and a long distance from the main channel of the Columbia. No modification is required.

- **Glade Creek Highway 14 Bridge.** The Highway 14 Bridge over Glade Creek is outside of the reservoir backwater. The bottom of footing elevation is 245 feet NGVD. Because of delta formation downstream of the bridge, it is assumed that drawdown could not create a head cut that reaches the bridge. Therefore no modification is required.

- **Glade Creek BNSF Railroad Bridge.** The BNSF Bridge over Glade Creek is several hundred feet downstream of the Highway 14 Bridge. The top of spread footing elevation is 239 feet NGVD, and the footings are set in bedrock. No modification is required.

The evaluation of bridges has shown just two bridges that need to be mitigated. They are the Highway 14 and BNSF Railroad bridges over Rock Creek. Both of these bridges need to be mitigated because they would create a blockage for fish migrating upstream, if the reservoir is drawn down.

4.3 Evaluation of Culverts

Culverts were screened into three categories. Those categories include: (1) those that spill directly onto the embankments bordering the reservoir, (2) those that are significantly away from the reservoir, or outlet onto a delta that is sufficiently large and vegetated, or (3) those that would be perched (leaving ponded water trapped upstream) if the reservoir is drawn down. Modification is required for the culverts that fall into the first or third category.

The culverts that were visited in the field were categorized first, using information from the data sheets and photos. The remaining culverts (those that were listed in the inventory but not visited) were then categorized by identifying their locations on 1:24,000 scale USGS maps, and then determining whether it spilled directly onto the reservoir embankment, or was a sufficient distance away from the reservoir. The analysis produced a total of 159 culverts that spilled directly onto the embankment, 185 culverts that were set back from the reservoir or discharged into a large delta, and nine culverts that would be perched after drawdown.

For the 185 culverts that are set back from the reservoir, no modification is needed. All nine culverts that potentially may be perched needs to be individually mitigated. The remaining 159 culverts that also need modification were further divided into five groups based on location in the pool (river mile), and into three sizes. The smallest size were those culverts that were two feet in diameter or less. The medium size culverts were those greater than two feet, but less than or equal to four feet in diameter. The large culverts were all those greater than four feet in diameter. The breakdown is shown in the table below.

Table 4-1: Number of Culverts Spilling onto Embankments.

	Washington			Oregon		
	Small (#2 ft)	Med. (2-4 ft)	Large (>4 ft)	Small (#2 ft)	Med. (2-4 ft)	Large (>4 ft)
Group I (RM 216- 235)	10	51	14	0 (10)*	7 (51)*	7
Group II (RM 235- 250)	2	30	7	0 (2)*	3 (30)*	2
Group III (RM 250-265)	0	14	3	0	1	1
Group IV (RM 265-282)	1	1	1	0	2	0
Group V (RM 282-292)	0	0	0	0	0	0
Total **	13	96	25	12	84	10

*Assumed number of culverts on Oregon side is equal to the Washington side.
** Total includes the estimated number of culverts assumed to be on the Oregon side.

The inventory shows many more culverts on the Washington (north) side of the reservoir than the Oregon (south) side. This is because the BNSF track profile has a much more comprehensive list of culverts than the UP track profile. It appears that the UP track profile shows all of the large culverts, but does not include many of the smaller culverts, that are really there. The field reconnaissance supports this, because several smaller culverts were observed on the Oregon side of the reservoir, but not found on the ODOT Bridge Log or UP track profile. As a conservative estimate, it was assumed that the Oregon side has the same number of small and medium culverts as the Washington side for Groups I and II. Groups I and II are very similar on both sides of the reservoir, in the sense that most of the rail lines are immediately adjacent to the water on both sides. By adding the estimated number of small and medium culverts on the Oregon side, the total number of culverts that spill onto the embankment which need mitigating is estimated to be 240.

5. MODIFICATION MEASURES

5.1 Modification of Bridges

There are two bridges that require modification. They are the Highway 14 and BNSF Railroad bridges over Rock Creek. Prior to the initial filling of the John Day Reservoir, the railway and road embankment was re-routed across Rock Creek, and completely blocked the original Rock Creek channel. A new channel was blasted through bedrock several hundred feet east of the original channel. Both bridges are currently set in bedrock, with the channel bottom also comprised of a bedrock sill. Following drawdown of the reservoir, this bedrock sill would block fish passage. The thalweg of the channel would need to be lowered. Furthermore, to achieve a stable channel for Rock Creek, the bridges would also have to be longer in order to achieve the required channel width. To provide fish passage, we propose to dredge the original channel and break through the existing embankment. This would require two new bridges over the opening in the abutment to carry Highway 14 and the BNSF Railroad.

5.1.1 Natural River Condition

For the Natural River condition, the new highway and railroad bridges need to be 460 feet long to accommodate the stable channel design. The thalweg would have to be lowered to an elevation of 202 feet NGVD. As well as two new bridges, this design would require the removal of 299,357 cubic yards of embankment fill.

5.1.2 Spillway Drawdown Condition

For the Spillway Drawdown condition, the new highway and railroad bridges need to be 330 feet long to accommodate the stable channel design. The thalweg would have to be lowered to an elevation of 234.8 feet NGVD. As well as two new bridges, this design would require the removal of 118,152 cubic yards of embankment fill.

5.2 Modification of Culverts

5.2.1 Perched Culverts

There are a total of nine culverts that would be perched after drawdown. They are: (1) the box culvert at the Blalock Canyon Boat Launch, (2) the box culvert at Jones Canyon, and (3) a group of seven culverts near River Mile 267. To drain the stagnant water that would be trapped upstream, these culverts would need to be replaced with culverts that are low enough to empty the entire pond and pass inflows. The modification for these will be virtually the same for Natural River and Spillway Drawdown scenarios. The only difference being that the culverts for the Natural River scenario would have to extend to a lower elevation to reach the drawn-down water surface than the culverts for the Spillway Drawdown scenario.

5.2.1.1 Natural River or Spillway Drawdown Condition

- **Blalock Canyon Boat Launch.** Add a 48-inch, 100 feet long corrugated metal pipe that has an inlet as low as the pond bottom. This modification will drain the water ponded behind the existing box culvert.

- **Jones Canyon Railroad Culvert.** Add a 48-inch, 100 feet long corrugated metal pipe that has an inlet at the same elevation as the pond bottom. This modification will drain the water behind the existing culvert.

- **Backwater Pond Culverts near River Mile 267.** There are seven culverts that drain backwater ponds behind I-84 and the UPRR embankment along a stretch of river near River Mile 267. There are three 36-inch culverts, about 1000 feet apart, which connect ponds on either side of I-84. There are three 48-inch culverts and one set of two 60-inch culverts that connect the pond behind the railroad embankment with the reservoir. They are also approximately 1000 feet apart. To mitigate the situation for drawdown, one 100-feet long, 8-feet diameter corrugated metal pipe would replace all the culverts in the railroad embankment. A 200-feet long, 8-feet diameter corrugated metal pipe would replace all the culverts in the I-84 embankment. The inlets of the 8-feet corrugated metal pipes should be low enough to allow the ponds to completely drain.

5.2.2 Culverts Spilling onto Embankments

5.2.2.1 Riprap Stability

Portions of the John Day reservoir are currently protected against wave action and culvert discharges by Class IV riprap (thickness of 2.5 feet). This size was based on conservative assumptions made by the Corps of Engineers, and the availability of rock for riprap protection in the vicinity of the reservoir. The following analysis of riprap stability for culverts spilling onto the embankments is based on the assumption that all riprap, whether existing or added, would be the same Class IV size.

The Abt-Wittler equation (Wittler, 1999) describes the median, $D_{50,}$ size of riprap required to protect an embankment from overtopping flows:

$$D_{50} = 0.6q^{0.56}\, C_s^{-0.67} \tan\forall^{-0.683} \left[\sin\forall / (2.65\cos\forall - 1)(\cos\forall \tan N - \sin\forall)\right]^{1.11} \quad (1)$$

where:
$\forall$ = $\tan^{-1}(S)$ = slope angle,
S = slope, up to the angle of repose,
C_s = $0.75 + (\log C_u^{6})^{-2}$ = coefficient of stability,
C_u = (D_{60} / D_{10}) = coefficient of uniformity,
N = angle of repose of mixture,
q = flow per unit width (cfs/ft),
D_{60} = 60^{th} percent finer riprap size (ft), and
D_{10} = 10^{th} percent finer riprap size (ft).

From this equation, the flow per unit width, q, for a given riprap D_{50} size is:

$$q = 2.49D_{50}^{1.79}\, C_s^{1.2} \tan\forall^{1.22} / [\sin\forall / (2.65\cos\forall - 1)(\cos\forall \tan N - \sin\forall)]^{1.98} \quad (2)$$

Assuming: D_{50} = 2.5 ft (Class 4 Riprap),
$\forall$ = 2:1 = 26.6° (Budai, 1999),
N = 45°, and
C_u = 3 (from field observations),

then the flow per unit width, q, is 8.7 cfs/feet.

Using a flow per unit width, q, of 8.7 cfs/ft and the Manning's equation, a maximum culvert slope can be estimated for different diameters.

$$q \cong Q/d = (1.486 /n)\, (Bd^2/4)\, (d/4)^{2/3}\, S_o^{1/2}/d \qquad (3)$$

where: Q = flow (cfs)
d = culvert diameter
n = Manning's n value
S_o = slope

To determine the maximum slope to pass a flow per unit width of "q" cfs/feet, Equation (3) is converted to:

$$S_o = [(q\ n\ d / 1.486)\, (4/Bd^2)\, (4/d)^{\,2/3}]^2 \qquad (4)$$

Using q = 8.7 cfs/feet, and n = 0.015, Equation (4) reduces to:

$$S_o = 0.08d^{-3.33} \qquad (5)$$

A table of maximum culvert slope for various culvert diameters is shown below.

The average slope of the culverts is estimated from the field investigation to be approximately 0.02. This is only a rough estimate, as there are many culverts with widely varying slopes, and there were no available data that specified the slope. Table 5-1 shows that for culverts 1.0 and 1.5 feet wide, Class IV riprap is adequate to withstand the maximum capacity flowing out of the culvert, because the maximum slope is greater than 0.02. For 2.0 feet

Table 5-1: Maximum Culvert Slope

Diameter (ft)	Slope
1.0	0.08
1.5	0.021
2.0	0.008
2.5	0.004
3.0	0.002

culverts the maximum slope is still close to 0.02. For culverts 2.5 feet and greater the maximum slope becomes far less than 0.02. For small culverts (2 feet in diameter or less), Class IV riprap is adequate to protect the embankments. Therefore, we assumed that culverts greater than 2 feet in diameter would require modification beyond simply placing Class IV riprap.

5.2.2.2 Modification Methods

There are approximately 240 culverts that spill directly onto embankments. Three different designs are proposed to mitigate these. For culverts less than or equal to 2 feet in diameter, Class IV riprap would extend down from the culvert to the drawn-down water surface. It is assumed that there currently is no riprap in place, the slope is 2:1, the flow from the culvert expands at a 4:1 ratio, and the thickness of the riprap to be installed is 5 feet (or twice the median riprap size).

To mitigate culverts greater than 2 feet and less than or equal to 4 feet in diameter, 48-in diameter semi-circular corrugated downspouts would be placed from the culvert outlet and extending to the drawn-down water surface. It is assumed that the slope is 2:1.

To mitigate culverts four feet in diameter and greater, grouted Class IV riprap would be placed from the culvert to a point where the flow has expanded to a flow per unit width less than 8.7 cfs/feet. Class IV riprap, without grout, would be placed from that point to the water surface. Again, we assumed that there currently is no riprap in place, the slope is 2:1, flow from the culvert expands at a 4:1 ratio, the thickness of the riprap blanket is five feet, and the porosity of the riprap is 0.5 (the grouted riprap is about 50 percent riprap and 50 percent grout).

5.2.2.3 Natural River Condition

5.2.2.3.1 Small Size Culverts

For small culverts less than two feet in diameter, modification using Class IV riprap from the outlet to the reservoir water surface is proposed. The riprap does not need to be grouted because the small culverts only convey a small amount of water, and the flow per unit width is less than 8.7 cfs/feet. The riprap spans the entire distance from the outlet to the water, expands at a 4:1 ratio, and is five feet thick. Table 5-2 summarizes the volume calculations from the riprap volume spreadsheets in Appendix C.

Table 5-2: Volume of Riprap for Small Culverts (Natural River)

Culvert Group	Number of Small Culverts	Overall Length to Water Surface per Culvert (ft)	Total Volume of Riprap (cu yards)
Group I (RM 216-235)	20	212.4	43,345
Group II (RM 235-250)	4	167.7	5,456
Group III (RM 250-265)	0	123.0	0
Group IV (RM 265-282)	1	78.3	313
Group V (RM 282-292)	0	33.5	0
Total			**49,115**

5.2.2.3.2 Medium Size Culverts

For each culvert group there is an average vertical distance and overall length to the water surface. The water surface elevation used is for a flow of 150,000 cfs. For Natural River conditions, the average vertical distance to the water surface, and overall length assuming a 2:1 slope, is shown in Table 5-3.

Table 5-3: Distance to Water from Culvert (Natural River)

	Average Vertical Distance to Water Surface (ft)	Overall Length to Water Surface (ft)
Group I (RM 216-235)	95	212.4
Group II (RM 235-250)	75	167.7
Group III (RM 250-265)	55	123.0
Group IV (RM 265-282)	35	78.3
Group V (RM 282-292)	15	33.5

By multiplying the number of culverts in each group (shown in Table 4-1) by the overall length to the water surface, a total length of modification can be determined. For culverts greater than two feet and less than or equal to four feet, the total length of 48" corrugated downspouts are shown below in Table 5-4.

Table 5-4: Total Length of Downspouts (Natural River)

	Number of Medium Culverts	Overall Length to Water Surface per Culvert (ft)	Total Length of Downspouts Required (ft)
Group I (RM 216-235)	102	212.4	21,664
Group II (RM 235-250)	60	167.7	10,062
Group III (RM 250-265)	15	123.0	1,845
Group IV (RM 265-282)	3	78.3	235
Group V (RM 282-292)	0	33.5	0
Total			**33,800**

5.2.2.3.3 Large Size Culverts

Using the Abt-Wittler Equation for overtopped riprap, it was determined that Class IV riprap at a 2:1 slope cannot withstand flows exceeding 8.7 cfs/feet. For this reason, the riprap at large culverts would need to be grouted. The grouted portion should extend down the embankment slope until the flow is less than 8.7 cfs/feet. By assuming a 4:1 expansion, and the culvert is flowing at full capacity, this distance can be determined. However, the capacities of the culverts need to be determined first. By assuming the slope equals 0.02, Manning's n equals 0.015, and the culvert is circular and flowing full, the culvert capacity can be calculated using Manning's Equation:

$$Q = 1.49/n \; A \; R^{2/3} S^{1/2} \tag{6}$$

where:
- R = hydraulic Radius = A/P,
- A = $BD^2/4$,
- D = culvert diameter,
- P = wetted perimeter = BD,
- S = slope, and
- n = Manning's roughness coefficient.

Assuming a 4:1 expansion, the distance the grouted riprap needs to extend can be determined by first calculating the riprap width that will produce a flow of 8.7 cfs/feet. Using this width, the length of the grouted riprap can then be calculated. Table 5-5 shows the maximum capacity, Q, the bottom width of grouted riprap, and the length of the grouted riprap needed, for the various sized culverts along the reservoir.

Table 5-5: Grouted Riprap Dimensions (Natural River)

Culvert Diameter (ft)	Maximum Capacity (cfs)	Bottom Width (ft)	Length (ft)
4.5	241	28	46
5	320	37	64
6	521	60	108
7	786	90	167
8	1122	129	242
9	1535	176	335
10	2033	234	447
14 (2 – 7' culverts)	1572	181	333
18 (3 – 6' culverts)	1563	180	323
30 (3 – 10' culverts)	6100	701	1342

For the smaller culverts that need a shorter distance of grouted riprap, plain Class IV riprap would be extended beyond the grouted riprap at the same expansion ratio of 4:1. As the culvert size increases, the grouted riprap should extend further, until eventually grouted riprap has to be extended all the way to the water, as is the case with all the culverts larger than 8 feet in diameter. Once the area dimensions of the grouted riprap and plain riprap are defined for each culvert, the volume of riprap and grout can be calculated. The volume of grout was calculated by assuming a porosity of 0.5 for Class IV riprap. The total volume of Class IV riprap required for large culverts is 67,933 cubic yards, and equals the total volume of grouted riprap plus the total volume of plain riprap. The total volume of grout required for large culverts is 20,065 cubic yards, and is equal to half the volume of grouted riprap. Table 5-6 summarizes the volume of riprap and grout. A calculation spreadsheet is shown in Appendix C.

Table 5-6: Total Riprap Volume (Natural River)

Culvert Width (feet)	Number of Culverts	Group	Total Volume of Grouted Riprap (cu yds)	Total Volume of Ungrouted Riprap (cu yds)
4.5	5	I	692	10,636
4.5	1	II	138	1303
4.5	1	III	138	665
5	3	I	738	6118
5	1	III	246	568
5	1	IV	246	110
6	3	I	1972.	5002
6	2	II	1315	1662
7	2	I	3005	1723
7	1	II	1502	17
8	3	I	7210	0
8	1	II	1550	0
8	1	IV	400	0
9	1	I	2443	0
9	1	III	905	0
10	1	I	2482	0
10	3	II	4838	0
14 (2 – 7’ culverts)	2	I	5279	0
18 (3 – 6’ culverts)	1	I	2797	0
30 (3 – 10’ culverts)	1	II	2234	0
TOTAL			**40,129**	**27,804**

5.2.2.4 Spillway Drawdown Condition

5.2.2.4.1 Small Size Culverts

For small culverts less than two feet in diameter, a modification of Class IV riprap from the outlet to the reservoir water surface is needed. The riprap does not need to be grouted because the small culverts only convey a small amount of water. The riprap spans the entire distance from the outlet to the water, expands at a 4:1 ratio, and is 5 feet thick. Table 5-7 summarizes the volume calculations from the riprap volume spreadsheets in Appendix C.

Table 5-7: Volume of Riprap for Small Culverts (Spillway Drawdown)

	Number of Small Culverts	Overall Length to Water Surface per Culvert (ft)	Total Volume of Riprap (cu yards)
Group I (RM 216-235)	20	96	9,282
Group II (RM 235-250)	4	94	1,772
Group III (RM 250-265)	0	92	0
Group IV (RM 265-282)	1	78.3	279
Group V (RM 282-292)	0	33.5	0
Total			**11,300**

5.2.2.4.2 Medium Size Culverts

For each culvert group, there is an average vertical distance and overall length to the water surface. The water surface elevation used is for a flow of 150,000 cfs. For spillway river conditions, the average vertical distance to the water surface, and overall length assuming a 2:1 slope, is shown in Table 5-8.

Table 5-8: Distance to Water from Culvert (Spillway Drawdown)

	Average Vertical Distance to Water Surface (ft)	Overall Length to Water Surface (ft)
Group I (RM 216-235)	43	96.2
Group II (RM 235-250)	42	93.9
Group III (RM 250-265)	41	91.7
Group IV (RM 265-282)	33	73.8
Group V (RM 282-292)	15	33.5

By multiplying the number of culverts in each group (shown in Table 4-1) by the overall length to the water surface, a total length of modification can be determined. For culverts greater than two feet and less than or equal to four feet, the total length of 48-in corrugated downspouts is shown in Table 5-9.

Table 5-9: Total Length of Downspouts (Spillway Drawdown)

	Number of Medium Culverts	Overall Length to Water Surface per Culvert (ft)	Total Length of Downspouts Required
Group I (RM 216-235)	102	96.2	9,812
Group II (RM 235-250)	60	93.9	5,634
Group III (RM 250-265)	15	91.7	1,376
Group IV (RM 265-282)	3	73.8	221
Group V (RM 282-292)	0	33.5	0
Total			**17,000**

5.2.2.4.3 Large Size Culverts

Using the Abt-Wittler Equation for overtopped riprap, it was determined that Class IV riprap at a 2:1 slope cannot withstand flows exceeding 8.7 cfs/feet. For this reason the riprap at large culverts needs to be grouted. The grouted portion has to extend down slope until the flow is less than 8.7 cfs/feet. Assuming a 4:1 expansion and that the culvert is flowing at full capacity, this distance can be determined. However, the capacities of the culverts need to be determined first. Assuming that the slope equals 0.02, Manning's n equals 0.015, and that the culvert is circular and flowing full, the culvert capacities can be calculated using Manning's Equation.

Assuming the 4:1 expansion, the distance the grouted riprap needs to extend can be determined by first calculating the riprap width that will produce a flow of 8.7 cfs/feet. Using the width, the length of the grouted riprap can be calculated. The following table shows the maximum capacity, Q, the bottom width of grouted riprap, and the length of the grouted riprap, for the various sized culverts along the reservoir.

Table 5-10: Grouted Riprap Dimensions (Spillway Drawdown)

Culvert Diameter (ft)	Maximum Capacity (cfs)	Bottom Width (ft)	Length (ft)
4.5	241	28	46
5	320	37	64
6	521	60	108
7	786	90	167
8	1122	129	242
9	1535	176	335
10	2033	234	447
14 (2 – 7' culverts)	1572	181	333
18 (3 – 6' culverts)	1563	180	323
30 (3 – 10' culverts)	6100	701	1342

For the smaller culverts which need a shorter distance of grouted riprap, plain Class IV riprap needs to be extended beyond the grouted riprap at the same expansion ratio of 4:1. As the culvert size increases, the grouted riprap must extend further, until eventually grouted riprap has to be extended all the way to the water, as is the case with all the culverts larger than five feet in diameter. Once the area dimensions of the grouted riprap and plain riprap are defined for each culvert, the volume of riprap and grout can be calculated. The volume of grout was calculated by assuming a porosity of 0.5 for Class IV riprap. The total volume of Class IV riprap required for large culverts is 19,250 cubic yards, and equals the total volume of grouted riprap plus the total volume of plain riprap. The total volume of grout required for large culverts is 7,800 cubic yards, and is equal to half the volume of grouted riprap. Table 5-11 summarizes the volume of riprap and grout. A calculation spreadsheet is shown in Table 2 in Appendix 1.

Table 5-11: Total Riprap Volume (Spillway Drawdown)

Culvert Width (ft)	Number of Culverts	Group	Total Volume of Grouted Riprap (cubic yards)	Total Volume of Ungrouted Riprap (cubic yards)
4.5	5	1	692	1851
4.5	1	2	138	348
4.5	1	3	138	327
5	3	1	738	815
5	1	3	246	228
5	1	4	246	75
6	3	1	1606	0
6	2	2	1025	0
7	2	1	1106	0
7	1	2	530	0
8	3	1	1713	0
8	1	2	547	0
8	1	4	362	0
9	1	1	589	0
9	1	3	542	0
10	1	1	607	0
10	3	2	1746	0
14 (2 – 7’ culverts)	2	1	1356	0
18 (3 – 6’ culverts)	1	1	749	0
30 (3 – 10’ culverts)	1	2	930	0
TOTAL			**15,605**	**3,644**

5.3 Quantity Take-Offs

Total quantities of bridges, fill removal, culvert replacements, downspouts, riprap, and grout are shown in two separate spreadsheets for the Natural River condition and the Spillway Drawdown condition.

Table 5-12: Quantity Spreadsheet (Natural River)

John Day Drawdown - Natural River						
WEST Consultants						
June 18, 1999						
BDIF	X	DESC1	UOM	QUANTY	CONTINGENCY	COST ($)
Work Breakdown Str.	0	Template of Drawdown-DAM REMOVAL	LS			
DA	1	TEMPLATE OF ONE DAM	LS			
DA03	2	RESERVOIRS	LS			
DA0301	3	RESERVOIRS	ACR			
	4	BRIDGES, ADDITIONAL			25%	
	5	ROCK CREEK BNSF RAILROAD				
	6	460' Railroad Bridge	EA	1		
	6	Fill Removal	CY	299357		
	5	ROCK CREEK HIGHWAY 14				
	6	460' Highway Bridge	EA	1		
	6	Fill Removal	CY	0		
	4	DRAINAGE, CONNECTED POND CULVERTS TO BE LOWERED			25%	
	5	BLALOCK CANYON BOAT LAUNCH				
	6	Add 48" CMP to drain ponded water	LF	100		
	5	JONES CANYON RAILROAD CULVERT				
	6	Add 48" CMP to drain ponded water	LF	100		
	5	CULVERTS TO BACKWATER PONDS NEAR RM 267				
	6	Replace culverts with 2 - 8' CMP's	LF	300		
	4	DRAINAGE, CULVERT OUTLET MODIFICATIONS			25%	
	5	CULVERTS LESS THAN 2' IN DIAMETER (25 Culverts)				
	6	Class IV Riprap	CY	49115		
	5	CULVERTS BETWEEN 2.5' AND 4' IN DIAMETER (179 Culverts)				
	6	48" corrugated semi-circular downspouts	LF	33790		
	5	CULVERTS GREATER THAN 4.5' IN DIAMETER (35 Culverts)				
	6	Class IV Riprap	CY	67933		
	6	Grout	CY	20065		
DA04	2	DAMS	LS			
DA05	2	LOCKS	LS			
DA06	2	FISH AND WILDLIFE FACILITIES	LS			
DA07	2	POWER PLANTS	LS			
DA08	2	ROADS,RAILROADS,& BRIDGES	LS			
DA09	2	CHANNELS AND CANALS	LF			
DA0901	3	CHANNELS	LF			
DA090113	4	TRAFFIC CONTROL	EA			
DA090115	4	INITIAL DREDGING			25%	
	5	John Day River	CY	0		
	5	Willow Creek	CY	1051755		
	5	Umatilla River	CY	41768		
	5	Rock Creek	CY	377275		
	4	AVERAGE ANNUAL MAINTENANCE DREDGING			25%	
	5	John Day River	CY	0		
	5	Willow Creek	CY	106000		
	5	Umatilla River	CY	0		
	5	Rock Creek	CY	19000		
	4	DISPOSAL AREA FOR INITIAL DREDGING			25%	
	5	John Day River	SF	0		
	5	Willow Creek	SF	2839739		
	5	Umatilla River	SF	112774		
	5	Rock Creek	SF	1018643		
	4	DISPOSAL AREA FOR ANNUAL MAINTENANCE DREDGING			25%	
	5	John Day River	SF	0		
	5	Willow Creek	SF	286200		
	5	Umatilla River	SF	0		
	5	Rock Creek	SF	51300		
DA14	2	RECREATION FACILITIES	LS			
DA18	2	CULTURAL RESOURCE PRESERVATION	LS			
DA19	2	BUILDINGS, GROUNDS, & UTILITIES	LS			

Table 5-13: Quantity Spreadsheet (Spillway Drawdown)

John Day Drawdown - Spillway Crest						
WEST Consultants						
June 18, 1999						
BDIF	XL	DESC1	UOM	QUANTY	CONTINGENCY	COST ($)
Work Breakdown Str.	0	Template of Drawdown-DAM REMOVAL	LS			
DA	1					
DA03	2	RESERVOIRS	LS			
DA0301	3	RESERVOIRS	ACR			
	4	BRIDGES, ADDITIONAL	EA		25%	
	4	ROCK CREEK BNSF RAILROAD	EA	1		
		330' Railroad Bridge				
	5	Fill Removal	CY	118152		
	4	ROCK CREEK HIGHWAY 14.	EA	1		
		330' Two-lane highway bridge.				
	5	Fill Removal		0		
	3	DRAINAGE, CONNECTED POND CULVERTS TO BE LOWERED			25%	
	4	BLALOCK CANYON BOAT LAUNCH				
	5	Add 48" CMP to drain ponded water	LF	100		
	4	JONES CANYON RAILROAD CULVERT				
	5	Add 48" CMP to drain ponded water	LF	100		
	4	CULVERTS TO BACKWATER PONDS NEAR RM 267				
	5	Replace culverts with 2 - 8' CMP's	LF	300		
	4	DRAINAGE, CULVERT OUTLET MODIFICATIONS	EA		25%	
	5	CULVERTS LESS THAN 2' IN DIAMETER (25 Culverts)	CY			
	6	Class IV Riprap	CY	7803		
	5	CULVERTS BETWEEN 2.5' AND 4' IN DIAMETER (179 Culverts)	CY			
	6	48" semi-circular downspouts	LF	16995		
	5	CULVERTS GREATER THAN 4.5' IN DIAMETER (35 Culverts)	LF			
	6	Class IV Riprap	CY	19249		
	6	Grout	CY	7803		
DA04	2	DAMS	LS			
DA05	2	LOCKS	LS			
DA06	2	FISH AND WILDLIFE FACILITIES	LS			
DA07	2	POWER PLANTS	LS			
DA08	2	ROADS,RAILROADS,& BRIDGES	LS			
DA09	2	CHANNELS AND CANALS	LF			
DA0901	3	CHANNELS	LF			
	4	TRAFFIC CONTROL	EA			
	4	INITIAL DREDGING			25%	
	5	John Day River	CY	0		
	5	Willow Creek	CY	468382		
	5	Umatilla River	CY	41768		
	5	Rock Creek	CY	53431		
	4	AVERAGE ANNUAL MAINTENANCE DREDGING			25%	
	5	John Day River	CY	0		
	5	Willow Creek	CY	70000		
	5	Umatilla River	CY	0		
	5	Rock Creek	CY	6000		
	4	DISPOSAL AREA FOR INITIAL DREDGING			25%	
	5	John Day River	SF	0		
	5	Willow Creek	SF	1264631		
	5	Umatilla River	SF	112774		
	5	Rock Creek	SF	144264		
	4	DISPOSAL AREA FOR ANNUAL MAINTENANCE DREDGING			25%	
	5	John Day River	SF	0		
	5	Willow Creek	SF	189000		
	5	Umatilla River	SF	0		
	5	Rock Creek	SF	16200		
DA14	2	RECREATION FACILITIES	LS			
DA18	2	CULTURAL RESOURCE PRESERVATION	LS			
DA19	2	BUILDINGS, GROUNDS, & UTILITIES	LS			

6. SUMMARY

For the Spillway Drawdown and Natural River Condition scenarios, structural impacts may occur to both culverts and bridges along the John Day Pool. There are more than 20 bridges and hundreds of culverts that border the reservoir. Due to the much lower pool elevation, scouring may occur to road and railroad embankments located below culvert outfalls. There is also the potential for failure of bridge piers due to scour.

The objectives of the shoreline impact analysis was to first identify what bridges and culverts could potentially be impacted by drawdown, then determine the type and extent of impact, and finally develop modification measures.

The analysis determined that the Highway 14 and BNSF Railroad bridges over Rock Creek would require modification. Prior to the initial filling of the John Day Reservoir, the railway and road embankment was re-routed across Rock Creek, and completely blocked the original Rock Creek channel. A new channel was blasted through bedrock several hundred feet east of the original channel. Both bridges are currently set in bedrock, with the channel bottom also comprised of a bedrock sill. Following drawdown of the reservoir, this bedrock sill would block fish passage. The thalweg of the channel would need to be lowered. Furthermore, to achieve a stable channel for Rock Creek, the bridges would also have to be longer in order to achieve the required channel width. To provide fish passage, we propose to dredge the original channel and break through the existing embankment. This would require two new bridges over the opening in the abutment to carry Highway 14 and the BNSF Railroad.

The analysis identified 240 culverts that spill directly onto the reservoir's embankment. Three different designs are proposed to mitigate these. For culverts less than or equal to two feet in diameter, Class IV riprap (median size 2.5 feet) would extend from the culvert to the water surface. To mitigate culverts greater than two feet and less than or equal to four feet in diameter, 48-in diameter semi-circular corrugated downspouts would be placed from the culvert outlet to the water surface. To modification culverts four feet in diameter and greater, grouted Class IV riprap would be placed from the culvert to a point where the flow has expanded to a flow per unit width less than 8.7 cfs/feet. Class IV riprap, without grout, would be placed from that point to the water surface.

7. REFERENCES

Budai, Chris, Personal Communication, U.S. Army Corps of Engineers, Portland District, June 8, 1999.

Wittler, Rod, Personal Communication, June 1999.

Plates

Appendix A

Bridge and Culvert Inventory

BRIDGE AND CULVERT INVENTORY

	Road Name	Number	Milepost	River Mile	Name	Bridge / Culvert	Category	Site Visit Y/N	D.A. (sq. mi.)	Description
					OREGON					
1	I-84 & UPRR	0P141	112.57	215.9	Helms Creek	C	5	Y	8.6	3 - 72" - 255' CMP's
2	UPRR		112.51	216.4		C	5	Y		5' CMP
3	UPRR		112.68	216.4	Pyburn Hollow	C	5	Y		4' CMP
4	I-84	001088	114.60	218.0	John Day River	B	1	Y	7872	1536' Bridge, Footings or piles on rock.
5	UPRR		114.09	218.0	John Day River	B	1	Y	7872	1092' Bridge, Footings on rock, piles at center pier.
6	UPRR		119.75	224.2		C	5	Y		4' CMP
7	I-84 & UPRR	0P301	123.93	227.6	Wildcat Creek (Philippi Canyon)	C	5	Y	4.8	2 - 82" - 438' CMP's
8	UPRR		124.45	228.6		C	3	Y		5' CMP
9	UPRR		125.45	229.7	Swanson Canyon	C	5	Y	2.5	5' CMP
10	I-84		126	229.7		C	5	Y		3' CMP
11	I-84		126.2	229.9		C	5	Y		3' CMP
12	I-84		126.4	230.1		C	5	Y		3' CMP
13	UPRR		128.38	232.4	Myers Canyon	C	5	Y	4.8	2 - 5' Steel Plate Pipes
14	I-84 & UPRR	0P302	129.48	233.2	Blalock Creek	C	5	Y	16.9	2 - 84" - 788' CMP's
15	UPRR		129.12	233.2	Blalock Canyon (Boat Tunnel)	C	4	Y		20' X 21' Reinforced Concrete Box
16	UPRR		129.9	234.0		C	5	Y		3' CMP
17	UPRR		129.99	234.0	No Name 3	C	5	Y	0.9	2 - 4' CMP's
18	UPRR		130.65	234.9		C	5	Y		3' CMP
19	UPRR		130.8	235.0		C	5	Y		2 - 4' CMP's
20	I-84	0P303	133.35	236.6	Lang Canyon	C	3	Y	6.5	84" - 610' Multiplate Pipe
21	UPRR		132.51	236.6	Lang Canyon	C	5	Y	6.5	2 - 5' CMP's
22	UPRR		133.31			C	5	N		4' CMP
23	I-84	0P305	135.86	239.7	Jones Canyon	C	3	Y	14.9	108" - 568' Multiplate Pipe
24	UPRR		135.46	239.7	Jones Canyon	C	4	Y	14.9	20' X 21' Reinforced Concrete Box
25	I-84	08820	137.92	241.4	Arlington Viaduct	B	1	Y	49.8	1463' Bridge, All piles on rock except pier 1.
26	UPRR		137.4	241.4	China Creek (Alkali Canyon)	B	1	Y	49.8	280' Bridge (4 - 70' DPG), All footings on rock.
27	UPRR		138.5	242.5		C	5	Y		4' CMP
28	UPRR		144.5	249.0		C	5	Y		4' CMP
29	UPRR		147.85	252.1		C	3	Y		4' CMP
30	I-84	09197	148.55E	252.2	Willow Creek	B	1	Y	855	340' Bridge, Bottom of footing elevation = 199.0
31	I-84	07520A	148.55W	252.2	Willow Creek	B	1	Y	855	292' Bridge, Bottom of footing elevation = 195.0
32	UPRR		148.18	252.2	Willow Creek	B	1	Y	855	660' Bridge (5 - 132' CPR-DPG), Pile tip elev. = 145'
33	I-84	09307A	151.75E	255.9	Three Mile Canyon Int.	B	1	Y	7.15	196' Bridge (Does not cross over waterway)
34	I-84	09307	151.75W	255.9	Three Mile Canyon Int.	B	1	Y	7.15	144' Bridge (Does not cross over waterway)
35	UPRR		151.47	255.9	Three Mile Canyon	B	1	Y	7.15	147' Bridge (3 - 49' CPR-BM) (Does not cross waterway)
36	I-84 & UPRR	0P438	154.31	259.0	PGE Drain Tun.(Six Mile Canyon)	C	5	Y	144	102" - 879' Mult Pipe
37	UPRR		154.02	259.0		C	5	Y		4' CMP
38	UPRR		160.55	265.6	No Name 8	C	3	Y	1.5	2 - 6' CMP's
39	I-84	07395E	160.99		Irrigation Ditch (No Name 8)	C	3	Y	1.5	8x4x311' RCBC
40	UPRR		161.18	266.2		C	5	Y		4' CMP

41	I-84			266.7	Backwater Pond	C	4	Y		3' CMP
42	UPRR		162.08	266.7	Backwater Pond	C	4	Y		4' CMP
43	I-84			266.9	Backwater Pond	C	4	Y		3' CMP
44	UPRR		162.31	266.9	Backwater Pond	C	4	Y		4' CMP
45	I-84			267.3	Backwater Pond	C	4	Y		3' CMP
46	UPRR		162.71	267.3	Backwater Pond	C	4	Y		4' CMP
47	UPRR		163		Backwater Pond	C	4	Y		2 - 5' CMP's
48	UPRR			270.5	Backwater Pond	C	5	Y		4' CMP
49	I-84	05333	166.04		Irrigation Ditch	C	3	N		3x3x310' RCBC
50	I-84	05202A	167.54		USRS Canal	C	3	N		8x6 - 275' RCBC
51	I-84	05202B	F167.54		USRS Canal, Ditchrider Rd 28-Rt	B	3	N		
52	I-84	05202C	F167.54		USRS Canal, Ditchrider Rd 28-Lt	B	3	N		
53	UPRR		169.11		Irrigation Canal	C	3	N		8' X 6' RCB
54	730	08885	168.86		USRS Canal	B	3	N		
55	730	08886	174.25		Irrigation Canal	B	3	N		6x4 RCBC Siphon
56	730	00624A	182.60	289.0	Umatilla River (Umatilla 4-Bridge)	B	1	Y	2292	432' Bridge, All footings on rock.
57				289.0	Umatilla Pedestrian Bridge	B	1	Y	2292	195' Footbridge, Footings unknown.
58	I-82	02230	Y184.89	290.4	Columbia River WA-OR State Line	B	1	Y		Drawdown will not change hydraulics at bridge significantly
					WASHINGTON					
59	BNSF		120.56	215.8		C	5	N		48" CMP 184'
60	BNSF		120.80	216.0		C	5	N		42" CMP 171'
61	BNSF		120.88	216.1		C	5	N		36" CMP 279'
62	BNSF		120.89	216.1	Boat Tunnel	C	5	Y		22' SP 188'
63	BNSF		121.33	216.5		C	5	N		36" CMP 78'
64	BNSF		121.61	216.8		C	5	N		42" CMP 360'
65	BNSF		121.66	216.9		C	5	N		42" CMP 122'
66	BNSF		121.98	217.2		C	5	N		30" CMP 38'
67	BNSF		122.30	217.5		C	5	N		54" CMP 144'
68	BNSF		122.58	217.8		C	5	N		30" CMP 30'
69	BNSF		122.79	218.0		C	5	N		36" CMP 38'
70	BNSF		123.09	218.3		C	5	N		54" CMP 120'
71	BNSF		123.22	218.4		C	5	N		30" CMP 36'
72	BNSF		123.29	218.5		C	5	N		30" CMP 36'
73	BNSF		123.55	218.8		C	5	N		48" CMP 154'
74	BNSF		123.83	219.0		C	5	N		48" CMP 46'
75	BNSF		124.03	219.2		C	5	N		36" CMP 38'
76	BNSF		124.26	219.5		C	5	N		42" CMP 54'
77	BNSF		124.36	219.6		C	5	N		42" CMP 110'
78	BNSF		124.46	219.7		C	5	N		42" CMP 108'
79	BNSF		124.55	219.8		C	5	N		36" CMP 70'
80	BNSF		124.89	220.1		C	5	N		48" CMP 147'
81	BNSF		125.02	220.2		C	5	N		29"X18" CMA 56'
82	BNSF		125.28	220.5		C	5	N		29"X18" CMA 54'
83	BNSF		125.45	220.7		C	5	N		29"X18" CMA 54'
84	BNSF		125.58	220.8		C	5	N		29"X18" CMA 70'
85	BNSF		125.67	220.9		C	5	N		29"X18" CMA 52'
86	BNSF		125.74	221.0		C	5	N		29"X18" CMA 40'
87	BNSF		125.88	221.1		C	5	N		24" CMP 46'
88	BNSF		125.95	221.2		C	5	N		24" CMP 48'
89	BNSF		126.18	221.4		C	5	N		54" CMP 131'
90	BNSF		126.27	221.5		C	5	N		29"X18" CMA 40'
91	BNSF		126.52	221.7		C	5	N		48" CMP 110'
92	BNSF		126.66	221.9		C	5	N		43"X27" CMA 40'
93	BNSF		126.94	222.2		C	5	N		29"X18" CMA 38'
94	BNSF		127.17	222.4		C	5	N		43"X27" CMA 42'
95	BNSF		127.61	222.8		C	5	N		84" SP 129'
96	BNSF		127.69	222.9		C	5	N		84" SP 149'
97	BNSF		127.80	223.0		C	5	N		72" SP 149'

98	BNSF		127.98	223.0		C	5	N		29"X18" CMA 38'
99	BNSF		128.28	223.1	Ju Canyon	C	5	Y	2.8	108" SP 133'
100	BNSF		128.44	223.2		C	5	N		30" CMP 76'
101	BNSF		128.55	223.3		C	5	N		29"X18" CMA 42'
102	BNSF		128.68	223.4		C	5	N		29"X18" CMA 56'
103	BNSF		128.88	223.5		C	5	N		30" CMP 52'
104	BNSF		129.04	223.6		C	5	N		60" SP 192'
105	BNSF		129.20	223.8		C	5	N		36" CMP 46'
106	BNSF		129.45	224.0		C	5	N		36" CMP 163'
107	BNSF		129.55	224.1	No Name 1	C	3	Y	5.1	120" SP 148'
108	BNSF		129.64	224.3		C	3	N		42" CMP 163'
109	BNSF		129.78	224.4		C	3	N		29"X18" CMA 38'
110	BNSF		129.90	224.5		C	3	N		29"X18" CMA 46'
111	BNSF		130.02	224.6		C	3	N		29"X18" CMA 40'
112	BNSF		130.22	224.8		C	3	N		29"X18" CMA 44'
113	BNSF		130.37	225.0		C	3	N		29"X18" CMA 42'
114	BNSF		130.68	225.3	Sand Spring Canyon	C	3	Y	4.8	120" SP 160'
115	BNSF		130.76	225.4		C	3	N		29"X18" CMA 102'
116	BNSF		130.94	225.6		C	3	N		29"X18" CMA 40'
117	BNSF		131.23	226.0		C	3	N		42" CMP 66'
118	BNSF		131.49	226.5		C	3	N		24" CMP 46'
119	BNSF		131.64	226.6		C	3	N		29"X18" CMA 38'
120	BNSF		131.87	226.8	No Name 2	C	3	N	1	78" SP 62'
121	BNSF		132.02	227.0		C	3	N		30" CMP 82'
122	BNSF		132.23	227.2		C	3	N		30" CMP 66'
123	BNSF		132.44	227.4		C	3	N		43"X27" CMA 46'
124	BNSF		132.69	227.8		C	5	N		29"X18" CMA 44'
125	BNSF		132.76	227.9		C	5	N		30" CMP 97'
126	BNSF		132.86	228.0		C	5	N		29"X18" CMA 38'
127	BNSF		133.32	228.6		C	5	N		29"X18" CMA 40'
128	BNSF		133.45	228.7		C	5	N		CULV
129	BNSF		133.56	228.9		C	5	N		30" CMP 91'
130	BNSF	BR 133.7	133.67	229.0	Rock Creek	B	2	Y	226	CBG 122', Abutments set in rock.
131	SR 14	06790A	121.09	229.0	Rock Creek	B	2	Y	226	118 CBOX, Abutments set in rock.
132	BNSF		133.77	229.1		C	5	N		24" CMP 71'
133	BNSF		133.87	229.2		C	5	N		24" CMP 61'
134	BNSF		134.37	229.7		C	5	N		66" SP 205'
135	BNSF		134.59	229.9		C	5	N		30" CMP 57'
136	BNSF		134.67	230.0		C	5	N		24" CMP 39'
137	BNSF		134.78	230.1		C	5	N		36" CMP 55'
138	BNSF		134.91	230.2		C	5	N		24" CMP 53'
139	BNSF		135.30	230.6		C	5	Y		90" SP 163'
140	BNSF		135.55	230.9		C	5	N		30" CMP 71'
141	BNSF		135.89	231.2		C	5	N		48" CMP 67'
142	BNSF		136.02	231.4		C	5	N		30" CMP 67'
143	BNSF		136.31	231.7		C	5	N		54" CMP 100'
144	BNSF		136.41	231.8		C	5	N		54" CMP 130'
145	BNSF		136.81	232.2		C	5	N		96" SP 133'
146	BNSF		137.44	232.8		C	5	N		24" CMP 66' w/ 18" CMP EXT 59'
147	BNSF		137.81	233.4		C	5	N		CMP 88'
148	BNSF		138.14	233.7		C	5	N		30" CMP 140'
149	BNSF		138.53	234.0		C	5	N		48" CMP 55'
150	BNSF		138.77	234.2		C	5	N		43"X27" CMA 35'
151	BNSF		139.10	234.5		C	5	Y		72" SP 162'
152	BNSF		139.28	234.7		C	3	N		24" CMP 46'
153	BNSF		139.46	234.9		C	5	N		24" CMP 167'
154	BNSF		139.49	234.9		C	5	N		36" CMP 165'
155	BNSF		140.04	235.4		C	3	N		43"X27" CMA 50'
156	BNSF		140.38	235.8		C	5	N		24" CMP 66' w/ 18" CMP EXT 59'
157	BNSF		140.94	236.3		C	5	N		66" SPP 358'
158	BNSF	BR 141.1	141.05	236.5	Chapman Creek	B	1	Y	24.1	PSG 135', Footings and

										piles on rock.
159	BNSF		141.19	236.6		C	5	N		29"X18" CMA 40'
160	BNSF		141.44	236.9		C	5	N		29"X18" CMA 38'
161	BNSF		141.60	237.0		C	5	N		29"X18" CMA 38'
162	BNSF		141.86	237.3		C	5	N		29"X18" CMA 36'
163	BNSF		141.98	237.4		C	5	N		36" CMP 42'
164	BNSF		142.07	237.5		C	5	N		36" CMP 87'
165	BNSF		142.22	237.7		C	5	N		29"X18" CMA 36'
166	BNSF		142.45	237.9		C	5	N		36"X22" CMA 40'
167	BNSF		142.50	238.0	Old Lady Canyon	C	5	Y	19.2	120" SP 156'
168	BNSF		142.70	238.1		C	5	N		36" CMP 95'
169	BNSF		142.92	238.3		C	5	N		29"X18" CMA 36'
170	BNSF		143.03	238.4		C	5	N		36"X22" CMA 38'
171	BNSF		143.25	238.6		C	5	N		36" CMP 40'
172	BNSF		143.48	238.8		C	5	N		29"X18" CMA 36'
173	BNSF		143.70	239.0		C	5	N		29"X18" CMA 43'
174	BNSF		143.85	239.2		C	5	N		30" CMP 55'
175	BNSF		143.98	239.3		C	5	N		36" CMP 89'
176	BNSF		144.24	239.6		C	5	N		29"X18" CMA 36'
177	BNSF		144.47	239.8		C	5	N		29"X18" CMA 36'
178	BNSF		144.60	239.9		C	5	N		29"X18" CMA 36'
179	BNSF		144.84	240.2		C	5	N		29"X18" CMA 36'
180	BNSF		144.92	240.3		C	5	N		29"X18" CMA 36'
181	BNSF		145.13	240.5		C	5	N		29"X18" CMA 36'
182	BNSF		145.17	240.5		C	5	N		15" CMP SLEEVE 76'
183	BNSF		145.29	240.6		C	3	N		30" CMP 95'
184	BNSF		145.65	241.2		C	3	N		29"X18" CMA 36'
185	BNSF		145.65	241.2		C	3	N		CULV
186	BNSF		145.92	241.7		C	3	N		30" CMP 57'
187	BNSF		146.14	242.0		C	3	N		CULV
188	BNSF		146.37	242.3		C	3	N		29"X18" CMA 36'
189	BNSF		146.72	242.7		C	3	N		36" CMP 107'
190	BNSF	BR 147.0	147.01	243.0	Wood Gulch	B	1	Y	63.8	CG 205', Footings on bedrock.
191	SR 14	05849A	134.29	243.0	Wood Creek	B	1	Y	63.8	15 CS, Bridge out of backwater.
192	BNSF		147.87	243.9		C	3	N		54" CMP 144'
193	BNSF		148.20	244.2		C	3	N		42" CMP 178'
194	BNSF		148.48	244.5		C	3	N		36" CMP 105'
195	BNSF		148.79	244.8		C	3	N		42" CMP 72'
196	BNSF		148.88	244.9		C	3	N		42" CMP 121'
197	BNSF		149.02	245.0		C	3	N		30" CMP 68'
198	BNSF		149.08	245.1		C	3	N		36" CMP 68'
199	BNSF		149.20	245.2		C	3	N		30" CMP 70'
200	BNSF		149.28	245.3		C	5	N		30" CMP 58'
201	BNSF		149.37	245.4		C	5	N		30" CMP 58'
202	BNSF		149.45	245.5		C	5	N		30" CMP 60'
203	BNSF		149.49	245.5		C	5	N		42" CMP 113'
204	BNSF		149.71	245.6		C	5	N		29"X18" CMA 58'
205	BNSF		149.82	245.7	No Name 4	C	5	Y	0.8	66" SPP 136'
206	BNSF		149.87	245.8		C	5	N		48" CMP 113'
207	BNSF		149.97	245.9		C	5	N		30" CMP 60'
208	BNSF		150.16	246.1		C	5	N		54" CMP 113'
209	BNSF		150.27	246.2		C	5	N		30" CMP 62'
210	BNSF		150.37	246.3		C	3	N		42" CMP 85'
211	BNSF		150.45	246.4		C	3	N		30" CMP 52'
212	BNSF		150.59	246.5		C	3	N		30" CMP 59'
213	BNSF		150.88	246.8	No Name 5	C	5	Y	1.2	84" SPP 122'
214	BNSF		150.96	246.9		C	3	N		30" CMP 93'
215	BNSF		151.11	247.0		C	3	N		30" CMP 81'
216	BNSF		151.25	247.2		C	3	N		54" CMP 109'
217	BNSF		151.31	247.2		C	3	N		30" CMP 76'
218	BNSF		151.42	247.4		C	3	N		30" CMP 61'
219	BNSF		151.58	247.5		C	3	N		54" CMP 64'
220	BNSF		151.71	247.6		C	3	N		30" CMP 56'

221	BNSF		151.84	247.8		C	3	N		30" CMP 50'
222	BNSF		151.93	247.9		C	3	N		30" CMP 50'
223	BNSF		152.05	248.0		C	3	N		36" CMP 74'
224	BNSF		152.24	248.2		C	3	N		30" CMP 50'
225	BNSF		152.27	248.2		C	3	N		30" CMP 50'
226	BNSF		152.55	248.5		C	3	N		30" CMP 76'
227	BNSF		152.69	248.6		C	3	N		48" CMP 95'
228	BNSF		152.86	248.8		C	3	N		36" CMP 70'
229	BNSF		153.05	249.0		C	3	N		42" CMP 57'
230	BNSF		153.38	249.3		C	3	N		30" CMP 99'
231	BNSF		153.49	249.4		C	5	N		CULV
232	BNSF & SR 14		153.54	249.5	Pine Creek	C	5	Y	58.7	120" SPP 426'
233	BNSF & SR 14		153.57	249.5	Pine Creek	C	5	Y	58.7	120" TRIPLE SPP 238'
234	BNSF		153.87	249.8		C	3	N		30" CMP 44'
235	BNSF		153.97	249.9		C	3	N		30" CMP 76'
236	BNSF		154.07	250.0		C	3	N		30" CMP 57'
237	BNSF		154.27	250.1		C	3	N		30" CMP 55'
238	BNSF		154.36	250.2		C	3	N		42" CMP 49'
239	BNSF		154.49	250.4		C	3	N		30" CMP 51'
240	BNSF		154.61	250.5		C	3	N		30" CMP 71'
241	BNSF		154.73	250.6		C	3	N		30" CMP 75'
242	BNSF		154.77	250.6		C	3	N		30" CMP 81'
243	BNSF		154.94	250.8		C	3	N		30" CMP 63'
244	BNSF		155.10	251.0		C	3	N		30" CMP 81'
245	BNSF		155.32	251.2		C	3	N		30" CMP 79'
246	BNSF		155.42	251.4		C	3	N		30" CMP 87'
247	BNSF		155.66	251.6		C	3	N		30" CMP 55'
248	BNSF		156.04	252.0		C	3	N		30" CMP 89'
249	BNSF		156.22	252.2		C	3	N		30" CMP 89'
250	BNSF		156.42	252.4		C	3	N		30" CMP 69'
251	BNSF		156.59	252.6		C	3	N		29"X18" CMA 46'
252	BNSF		156.64	252.7	No Name 6	C	3	Y	1.7	108" SPP 102'
253	BNSF		156.78	252.9		C	3	N		30" CMP 87'
254	BNSF		156.93	253.0		C	3	Y		42" CMP 75'
255	BNSF		156.96	253.0		C	3	N		42" CMP 65'
256	BNSF		157.09	253.2		C	3	N		36" CMP 109'
257	BNSF		157.20	253.3		C	3	N		42" CMP 101'
258	BNSF		157.41	253.5		C	3	N		72" SPP 108'
259	BNSF		157.69	253.7		C	3	N		29"X18" CMA 55'
260	BNSF		157.87	253.7		C	3	N		30" CMP 85'
261	BNSF		158.12	254.0		C	3	N		36" CMP 129'
262	BNSF		158.23	254.1	No Name 7	C	3	Y	1.2	84" SP 99'
263	BNSF		158.44	254.3		C	3	N		30" CMP 58'
264	BNSF		158.56	254.4		C	5	N		36" CMP 77'
265	BNSF		158.63	254.5		C	5	N		30" CMP 62'
266	BNSF		158.93	254.8		C	5	N		30" CMP 50'
267	BNSF		159.19	255.1		C	5	N		54" CMP
268	BNSF		159.46	255.3		C	5	N		48" CMP 118'
269	BNSF		159.64	255.5		C	5	N		30" CMP 53'
270	BNSF		159.96	255.8		C	5	N		60" CMP 128'
271	BNSF		160.11	256.0		C	5	N		36" CMP 79'
272	BNSF		160.38	256.3		C	5	N		36" CMP 72'
273	BNSF		160.55	256.4		C	5	N		30" CMP 72'
274	BNSF		160.73	256.6		C	5	N		CULV
275	BNSF		160.81	256.7		C	5	N		CULV
276	BNSF		160.95	256.8		C	5	N		36" CMP 51'
277	BNSF		161.19	257.1		C	3	N		48" CMP 50'
278	BNSF		161.32	257.2		C	3	N		36" CMP 56'
279	BNSF		161.46	257.3		C	3	N		42" CMP 85'
280	BNSF	BR161.8	161.80	257.7	Alder Creek	B	1	Y	197	CG 210', Footings on rock.
281	SR 14	0000OD	149.06	257.7	Alder Creek	B	1	Y	197	218 PCB, Footings below rock line.
282	BNSF		162.27	258.2		C	3	N		18" CMP 44'
283	BNSF		162.47	258.4		C	3	N		36" CMP 99'
284	BNSF		162.69	258.6		C	5	N		29"X18" CMA 50'

285	BNSF		162.86	258.8		C	3	N		36" CMP 61'
286	BNSF		163.19	259.1		C	3	N		43"X27" CMA 44'
287	BNSF		163.43	259.3		C	3	N		CULV
288	BNSF		163.62	259.6		C	3	N		29"X18" CMA 40'
289	BNSF		163.86	259.9		C	3	Y		60" CMP 60'
290	BNSF		164.00	260.0		C	5	Y		42" CMP 161'
291	BNSF		164.36	260.4		C	5	N		30" CMP 59'
292	BNSF		164.71	260.7		C	5	N		90" CMP 42'
293	BNSF		164.96	260.0		C	3	N		24" CMP 38'
294	BNSF		165.31	260.3		C	3	N		30" CMP 72'
295	BNSF		165.38	260.4		C	3	N		18" CMP 54'
296	BNSF		165.48	260.5		C	3	N		78" SPP 103'
297	BNSF		165.92	260.9		C	3	N		36" CMP 53'
298	BNSF		166.05	262.0		C	3	Y		36" CMP 58'
299	BNSF		166.27	262.1		C	3	N		42" CMP 57'
300	BNSF		166.47	262.2		C	3	N		48" CMP 89'
301	BNSF		166.69	262.3		C	3	N		30" CMP 56'
302	BNSF		166.79	262.3		C	3	N		24" CMP 34'
303	BNSF		166.91	262.4		C	3	N		30" CMP 53'
304	BNSF		167.16	262.5		C	3	N		18" CMP 66'
305	BNSF		167.17	262.5		C	3	N		30" CMP 54'
306	BNSF		167.34	262.6		C	3	N		30" CMP 57'
307	BNSF		167.56	262.7		C	3	N		30" CMP 56'
308	BNSF		167.72	262.9		C	3	N		30" CMP 56'
309	BNSF	BR 167.9	167.93	263.0	Dead Canyon	B	1	Y	76.9	CG 151', Spread footings, Out of backwater
310	SR 14	0000OE	155.12	263.0	Dead Canyon	B	1	Y	76.9	169 PCB, Out of backwater.
311	BNSF		168.28	263.2		C	3	N		36" CMP 109'
312	BNSF		168.41	263.3		C	3	N		42" CMP 73'
313	BNSF		168.85	263.8		C	3	N		48" CMP 99'
314	BNSF		169.04	264.0		C	3	N		30" CMP 58'
315	BNSF		169.25	264.1		C	3	N		36" CMP 69'
316	BNSF		169.36	264.2		C	3	N		36" CMP 115'
317	BNSF		170.02	264.9		C	3	N		72" SP 115'
318	BNSF		170.23	265.0		C	3	N		30" CMP 92'
319	BNSF		170.44	265.3		C	3	N		30" CMP 72'
320	BNSF		170.82	265.8		C	3	N		30" CMP 72'
321	BNSF		170.90	265.9		C	3	N		48" CMP 121'
322	BNSF		171.15	266.1		C	3	N		48" CMP 155'
323	BNSF		171.26	266.2		C	3	N		42" CMP 138'
324	BNSF		171.60	266.6		C	3	N		48" CMP 153'
325	BNSF		172.05	267.0		C	3	N		36" CMP 63'
326	BNSF		172.48	268.0		C	3	N		24" CMP
327	BNSF		172.89	269.0		C	3	N		36" CMP 133'
328	BNSF		173.26	270.0		C	3	N		30" CMP 44'
329	BNSF		173.50	270.5		C	3	N		30" CMP 44'
330	BNSF		173.67	270.7		C	3	N		24" CMP 36'
331	BNSF		173.85	270.9		C	3	N		24" CMP 48'
332	BNSF		174.05	271.1		C	3	N		30" CMP 99'
333	BNSF		174.47	271.5		C	3	N		84" SP 84'
334	BNSF		174.55	271.6		C	3	N		24" CMP 44'
335	BNSF	BR 174.9	174.92	272.0	Glade Creek	B	1	Y	347	CG 210', Footings set in rock.
336	SR 14	06565A	161.95	272.0	Glade Creek	B	1	Y		158 CS, Bottom of footing elev. = 245 ft.
337	BNSF		175.62	272.6		C	5	N		15" CMP 46'
338	BNSF		175.71	272.7		C	5	N		36" CMP 151'
339	BNSF		175.87	272.9		C	5	N		60" CMP 143'
340	BNSF		176.33	273.4		C	3	N		42" CMP 40'
341	BNSF		176.63	273.6		C	3	N		48" CMP 145'
342	BNSF		176.98	273.8		C	3	Y		48" CMP 141'
343	BNSF		177.46	274.2		C	3	N		24" CMP 38'
344	BNSF		177.77	274.4		C	3	N		30" CMP 58'
345	BNSF		177.79	274.4		C	3	N		CULV
346	BNSF		178.80	275.0		C	3	N		36" CMP 38'

347	BNSF		179.02	275.3		C	3	N		CULV
348	BNSF		179.03	275.3		C	3	N		84" SP 64'
349	BNSF		179.26	275.5		C	3	N		CULV
350	BNSF		179.64	275.9		C	3	N		18" CMP 54'
351	BNSF		179.70	276.0	No Name 9	C	3	Y	0.8	60" CMP 87'
352	BNSF		180.01	276.3		C	3	N		54" CMP 67'
353	BNSF		180.60	276.6	No Name 10	C	3	Y	1.6	72" SP 60'
354	BNSF		180.75	276.7		C	3	N		24" CMP 36'
355	BNSF		181.35	277.3		C	3	N		72" SP 106'
356	BNSF		181.57	277.5		C	3	N		30" CMP 105'
357	BNSF		181.76	277.6		C	3	N		24" CMP 52'
358	BNSF		182.04	277.7		C	3	N		30" CMP 58'
359	BNSF		182.39	277.9		C	3	N		48" CMP 94'
360	BNSF		182.53	278.0		C	3	N		30" CMP 119'
361	BNSF		182.76	278.1		C	3	N		48" CMP 119'
362	BNSF	BR 183.1	183.11	278.4	Sumner Ranch Creek (No Name 11)	B	1	Y	42.6	CBG 82'
363	BNSF		183.31	278.5		C	3	N		30" CMP 73'
364	BNSF		183.80	279.0		C	3	N		30" CMP 87'
365	BNSF		183.90	279.1		C	3	N		30" CMP 87'
366	BNSF		184.05	279.2		C	3	N		30" CMP 54'
367	BNSF		184.22	279.5		C	3	N		30" CMP 80'
368	BNSF		184.46	279.9		C	3	N		36" CMP 110'
369	BNSF		184.76	280.0		C	3	N		30" CMP 60'
370	BNSF		184.89	280.1		C	3	N		30" CMP 56'
371	BNSF		185.13	280.7		C	3	N		30" CMP 54'
372	BNSF		185.42	281.3		C	3	N		42" CMP 70'
373	BNSF		186.98	283.4		C	3	N		24" CMP 34'
374	BNSF		187.41	283.9		C	3	N		CULV
375	BNSF		188.81	285.2		C	3	N		36" CP 43'
376	BNSF		189.93	286.5		C	3	N		36" CP 39'
377	BNSF	BR 190.6	190.59	287.1	Four Mile Canyon	B	1	N	91.4	WF 65'
378	BNSF		192.04	288.7		C	3	N		36" CP 83'
379	BNSF		193.90	291.0		C	3	N		36" CP 84'

Categories
1. No bridge modification required
2. Bridge needs to be mitigated.
3. No culvert modification is required. Culvert is located away from the reservoir, or there is a sufficiently large vegetated delta at the outlet.
4. Connected Pond. Culvert will be perched after drawdown.
5. Culvert spills directly onto embankment.

TOTALS

Category 1:	24	Bridges: 26
Category 2:	2	Culverts: 353
Category 3:	185	
Category 4:	5	
Category 5:	163	

Appendix B

Bridge and Culvert Data Sheets and Photographs

JOHN DAY POOL - BRIDGE INVESTIGATION SHEET

DATE	5/10
TIME	12:24PM

BRIDGE NAME	John Day River Bridge
BRIDGE #	00108B
WATERWAY CROSSED	John Day River
ROAD OR RAILROAD NAME	I-84
MILEPOST	MP 114.60
RIVER MILE	218.0

LENGTH:	1536'	WIDTH:	62'	TYPE:	Steel Truss

NUMBER OF BENTS: | NO OF PIERS PER BENT: 2 square columns.

PIER DESCRIPTION: 6 Bents in the water. 2 on the embankments. 2 Abut.

BACKWATER CONTROL: YES NO

AGGRADATION (Describe): ~~None~~ N/A

DEGRADATION (Describe): N/A

PIER / ABUTMENT RIPRAP: Large Angular riprap @ abuts, w/ smaller gravels & cobbles

CONSTRICTION: YES NO | PERCENT: 10

BED MATERIAL: SILT/CLAY SAND? GRAVEL COBBLE BOULDER BEDROCK NO OBS.

Describe:

Cannot observe. Sand is best guess.

OTHER OBSERVATIONS:

PHOTO INDEX	
PHOTO 1	Panorama looking D/S at bridge. 027
PHOTO 2	" " " .
PHOTO 3	
PHOTO 4	
PHOTO 5	

Photographs - John Day River

Photo No. OR7 – Panorama looking downstream at bridge.

JOHN DAY POOL - CULVERT INVESTIGATION SHEET

DATE	5/13
TIME	11:48 am

CULVERT NUMBER / NAME	OLD LADY CANYON
WATERWAY CROSSED	OLD LADY CANYON
ROAD OR RAILROAD NAME	BNRR
MILEPOST	142.50
RIVER MILE	238.0

TYPE	SPP
SHAPE	Circular
LENGTH	156'
SIZE	~~XX~~' 120"

BACKWATER CONTROL: YES NO

ELEVATION OF CULVERT RELATIVE TO W.S.:
Culvert invert ≈ 5' above W.S

OUTLET DESCRIPTION:
Drains out onto grouted riprap delta then into reservoir.

INLET DESCRIPTION:

EROSION (any observed, existing measures, etc...):

DEPOSITION:
Small amount of sand deposits at the outlet

OTHER OBSERVATIONS:
Culvert bottom filled with concrete.

PHOTO INDEX:		
7 PHOTO 1	Looking D/S @ inlet	WA52
5 PHOTO 2	Outlet	WA53
PHOTO 3		
PHOTO 4		

Photographs - Old Lady Canyon

Photo No. WA52 – Looking downstream at inlet.

Photo No. WA53 – Outlet.

Appendix C

Riprap Calculation Spreadsheet

NATURAL CONDITION

GROUTED RIPRAP VOLUMES

Culvert Width W_a (ft)	Number of Culverts	Culvert Capacity (cfs)	Bottom Width of Grouted Riprap (ft)	Length of Expansion of Grouted Riprap (ft)	Bottom Width at Water Surface (ft)	Total Length of Expansion to Water Surface (ft)	Description	Total Overall Volume per Culvert (cy)	Volume of Grouted Riprap per Culvert (cy)	Volume of Riprap per Culvert (cy)	Total Volume Grouted Riprap (cy)	Total Volume Riprap (cy)
4.5	5	241	28	46	111	212	Group I	2265.6	138.4	2127.2	691.8	10636.2
4.5	1	241	28	46	88	168	Group II	1441.8	138.4	1303.4	138.4	1303.4
4.5	1	241	28	46	66	123	Group III	802.9	138.4	664.6	138.4	664.6
5	3	320	37	64	111	212	Group I	2285.3	245.9	2039.4	737.7	6118.1
5	1	320	37	64	67	123	Group III	814.3	245.9	568.4	245.9	568.4
5	1	320	37	64	44	78	Group IV	356.3	245.9	110.4	245.9	110.4
6	3	521	60	108	112	212	Group I	2324.6	657.4	1667.2	1972.3	5001.5
6	2	521	60	108	90	168	Group II	1488.3	657.4	830.9	1314.9	1661.8
7	2	786	90	167	113	212	Group I	2363.9	1502.4	861.5	3004.9	1723.0
7	1	786	90	167	91	168	Group II	1519.4	1502.4	17.0	1502.4	17.0
8	3	1122	129	242	114	212	Group I	2403.3	2403.3	0.0	7209.8	0.0
8	1	1122	129	242	92	168	Group II	1550.4	1550.4	0.0	1550.4	0.0
8	1	1122	129	242	47	78	Group IV	399.8	399.8	0.0	399.8	0.0
9	1	1535	176	335	115	212	Group I	2442.6	2442.6	0.0	2442.6	0.0
9	1	1535	176	335	71	123	Group III	905.4	905.4	0.0	905.4	0.0
10	1	2033	234	447	116	212	Group I	2481.9	2481.9	0.0	2481.9	0.0
10	3	2033	234	447	94	168	Group II	1612.6	1612.6	0.0	4837.7	0.0
14	2	1572	181	333	120	212	Group I (2 - 7' culverts)	2639.3	2639.3	0.0	5278.5	0.0
18	1	1563	180	323	124	212	Group I (3 - 6' culverts)	2796.6	2796.6	0.0	2796.6	0.0
30	1	6100	701	1342	114	168	Group II (3 - 10' culverts)	2233.7	2233.7	0.0	2233.7	0.0
										TOTALS:	40129	27804

RIPRAP VOLUMES FOR CULVERTS SMALLER THAN 2 FT

Culvert Width (ft)	Number of Culverts	Culvert Capacity (cfs)	Bottom Width at Water Surface (ft)	Length of Expansion to Water Surface (ft)	Description	Volume of Riprap per Culvert (cy)	Total Volume of Riprap (cy)
2	20	28	108	212	Group I	2167.3	43345
2	4	28	86	168	Group II	1364.1	5456
2	1	28	41	78	Group IV	312.8	313

TOTAL: 49115

Total Volume of Class IV Riprap (cubic yards): 117048

Total Volume of Grout (cubic yards): 20065

SPILLWAY CONDITION

GROUTED RIPRAP VOLUMES

Culvert Width (ft)	Number of Culverts	Culvert Capacity (cfs)	Bottom Width of Grouted Riprap (ft)	Length of Expansion of Grouted Riprap (ft)	Bottom Width at Water Surface (ft)	Total Length of Expansion to Water Surface (ft)	Description	Total Overall Volume per Culvert (cy)	Volume of Grouted Riprap per Culvert (cy)	Volume of Riprap per Culvert (cy)	Total Volume of Grouted Riprap (cy)	Total Volume of Riprap (cy)
4.5	5	241	28	46	53	96	Group I	508.6	138.4	370.3	691.8	1851.3
4.5	1	241	28	46	51	94	Group II	486.5	138.4	348.1	138.4	348.1
4.5	1	241	28	46	50	92	Group III	465.7	138.4	327.4	138.4	327.4
5	3	320	37	64	53	96	Group I	517.5	245.9	271.6	737.7	814.8
5	1	320	37	64	51	92	Group III	474.2	245.9	228.3	245.9	228.3
5	1	320	37	64	42	74	Group IV	320.5	245.9	74.6	245.9	74.6
6	3	521	60	108	54	96	Group I	535.3	535.3	0.0	1606.0	0.0
6	2	521	60	108	53	94	Group II	512.5	512.5	0.0	1025.1	0.0
7	2	786	90	167	55	96	Group I	553.2	553.2	0.0	1106.3	0.0
7	1	786	90	167	54	94	Group II	529.9	529.9	0.0	529.9	0.0
8	3	1122	129	242	56	96	Group I	571.0	571.0	0.0	1712.9	0.0
8	1	1122	129	242	55	94	Group II	547.3	547.3	0.0	547.3	0.0
8	1	1122	129	242	45	74	Group IV	361.5	361.5	0.0	361.5	0.0
9	1	1535	176	335	57	96	Group I	588.8	588.8	0.0	588.8	0.0
9	1	1535	176	335	55	92	Group III	542.1	542.1	0.0	542.1	0.0
10	1	2033	234	447	58	96	Group I	606.6	606.6	0.0	606.6	0.0
10	3	2033	234	447	57	94	Group II	582.1	582.1	0.0	1746.3	0.0
14	2	1572	181	333	62	96	Group I (2 - 7' culverts)	677.9	677.9	0.0	1355.7	0.0
18	1	1563	180	323	66	96	Group I (3 - 6' culverts)	749.1	749.1	0.0	749.1	0.0
30	1	6100	701	1342	77	94	Group II (3 - 10' culverts)	929.9	929.9	0.0	929.9	0.0

TOTALS: 15605 3644

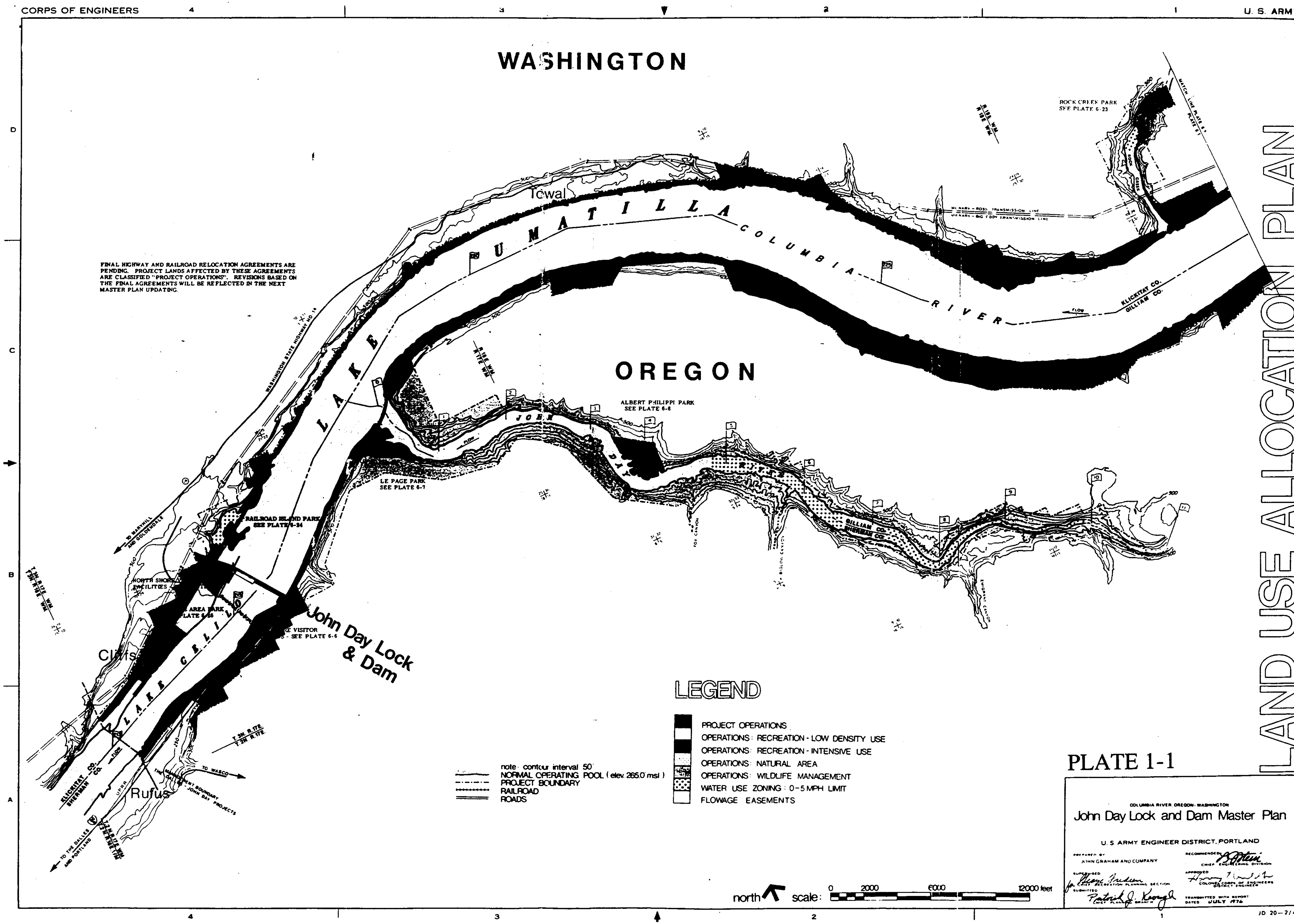
RIPRAP VOLUMES FOR CULVERTS SMALLER THAN 2 FT

Culvert Width (ft)	Number of Culverts	Culvert Capacity (cfs)	Bottom Width at Water Surface (ft)	Length of Expansion to Water Surface (ft)	Description	Volume of Riprap per Culvert (cy)	Total Volume of Riprap (cy)
2	20	28	50	96	Group I	464.1	9282
2	4	28	49	94	Group II	443.0	1772
2	1	28	39	74	Group IV	279.5	279

TOTAL: 11333

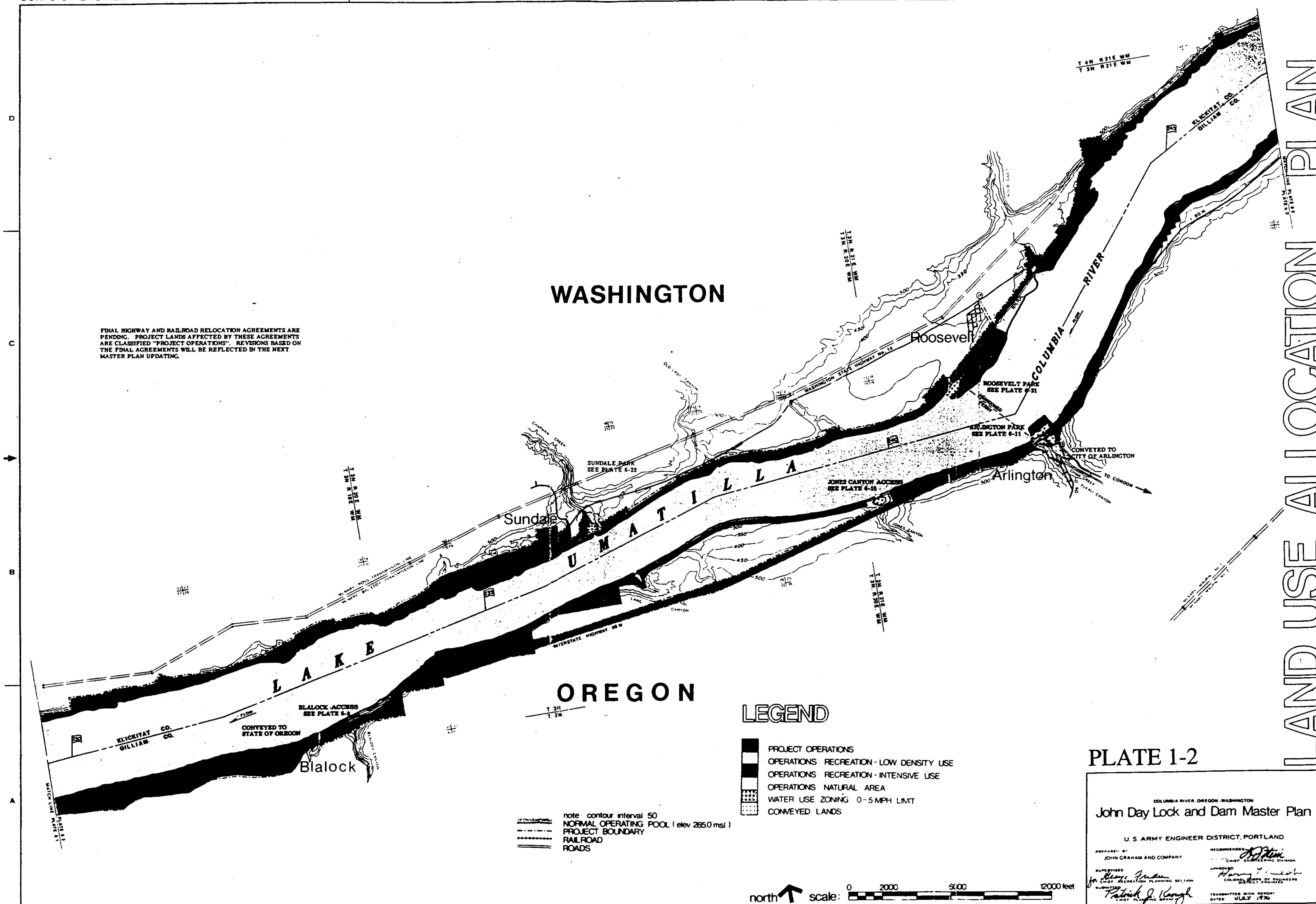
Total Volume of Class IV Riprap (cubic yards): 30583
Total Volume of Grout (cubic yards): 7803

Plates



CORPS OF ENGINEERS
U. S. ARMY
WASHINGTON
OREGON
LAND USE ALLOCATION PLAN
FINAL HIGHWAY AND RAILROAD RELOCATION AGREEMENTS ARE PENDING. PROJECT LANDS AFFECTED BY THESE AGREEMENTS ARE CLASSIFIED "PROJECT OPERATIONS". REVISIONS BASED ON THE FINAL AGREEMENTS WILL BE REFLECTED IN THE NEXT MASTER PLAN UPDATING.
LAKE UMATILLA
COLUMBIA RIVER
LAKE CELILO
JOHN DAY RIVER
ROCK CREEK PARK SEE PLATE 6-23
ALBERT PHILIPPI PARK SEE PLATE 6-8
LE PAGE PARK SEE PLATE 6-7
RAILROAD ISLAND PARK SEE PLATE 6-24
NORTH SHORE FACILITIES
WASHINGTON STATE HIGHWAY NO. 14
KLICKITAT CO.
GILLIAM CO.
SHERMAN CO.
Towal
Cliffs
Rufus
John Day Lock & Dam
TO WASCO
TO THE DALLES AND PORTLAND
TO MARYHILL AND GOLDENDALE
LEGEND
PROJECT OPERATIONS
OPERATIONS: RECREATION - LOW DENSITY USE
OPERATIONS: RECREATION - INTENSIVE USE
OPERATIONS: NATURAL AREA
OPERATIONS: WILDLIFE MANAGEMENT
WATER USE ZONING: 0-5 MPH LIMIT
FLOWAGE EASEMENTS
note: contour interval 50'
NORMAL OPERATING POOL (elev. 265.0 msl)
PROJECT BOUNDARY
RAILROAD
ROADS
north
scale: 0 2000 6000 12000 feet
PLATE 1-1
COLUMBIA RIVER OREGON-WASHINGTON
John Day Lock and Dam Master Plan
U. S. ARMY ENGINEER DISTRICT, PORTLAND
PREPARED BY JOHN GRAHAM AND COMPANY
TRANSMITTED WITH REPORT DATED JULY 1976
JD 20-2/4

CORPS OF ENGINEERS U.S. ARMY



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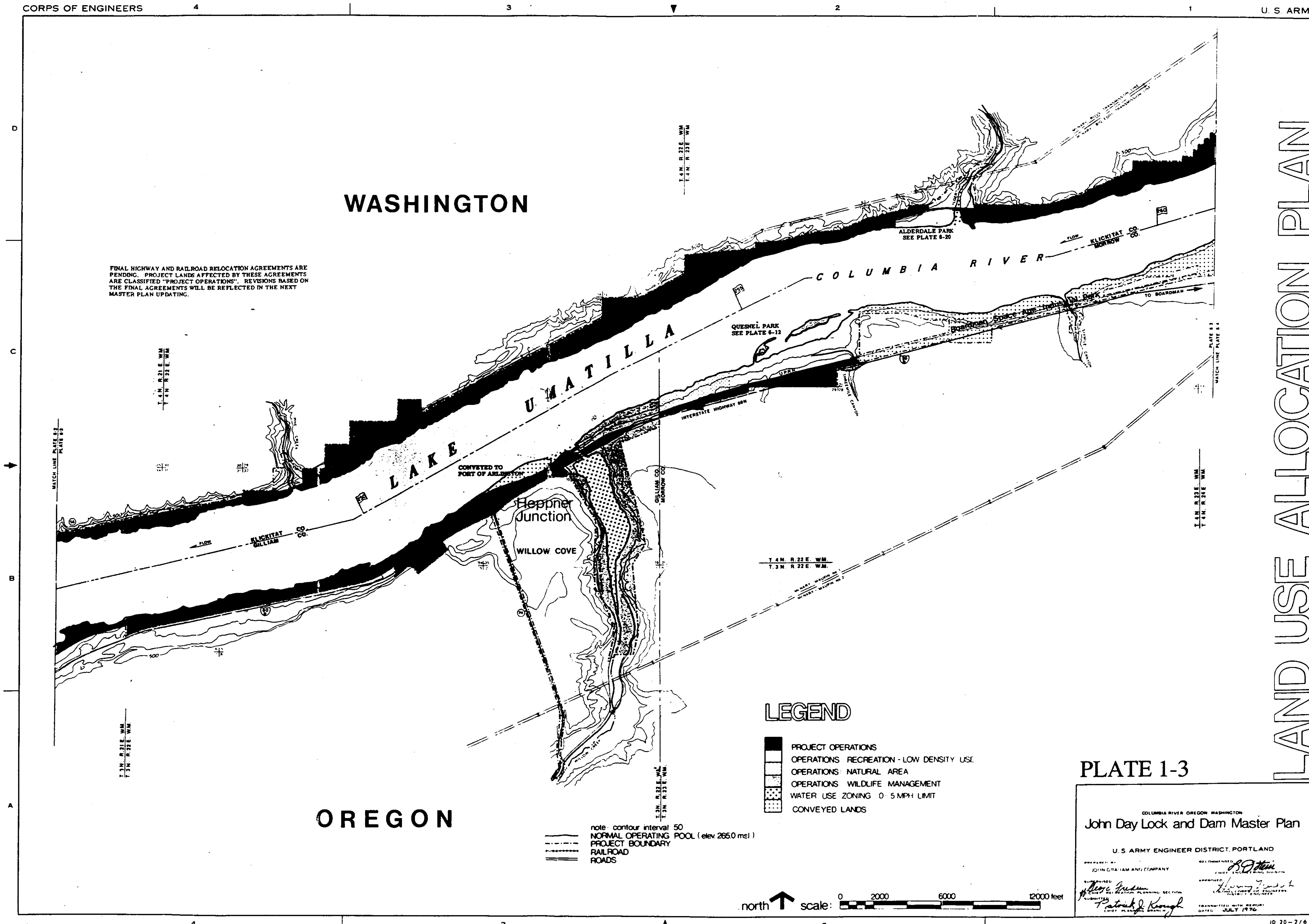
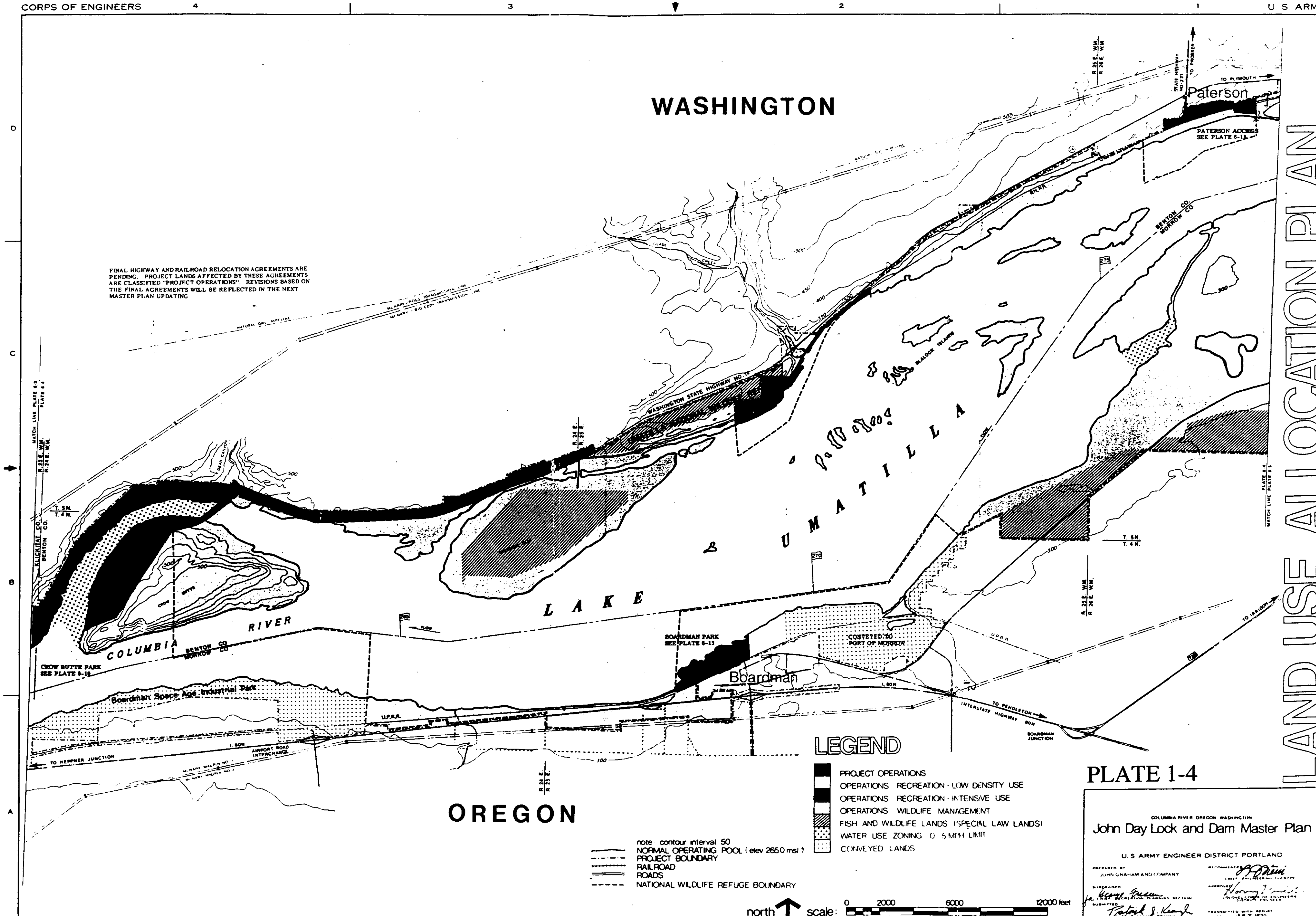
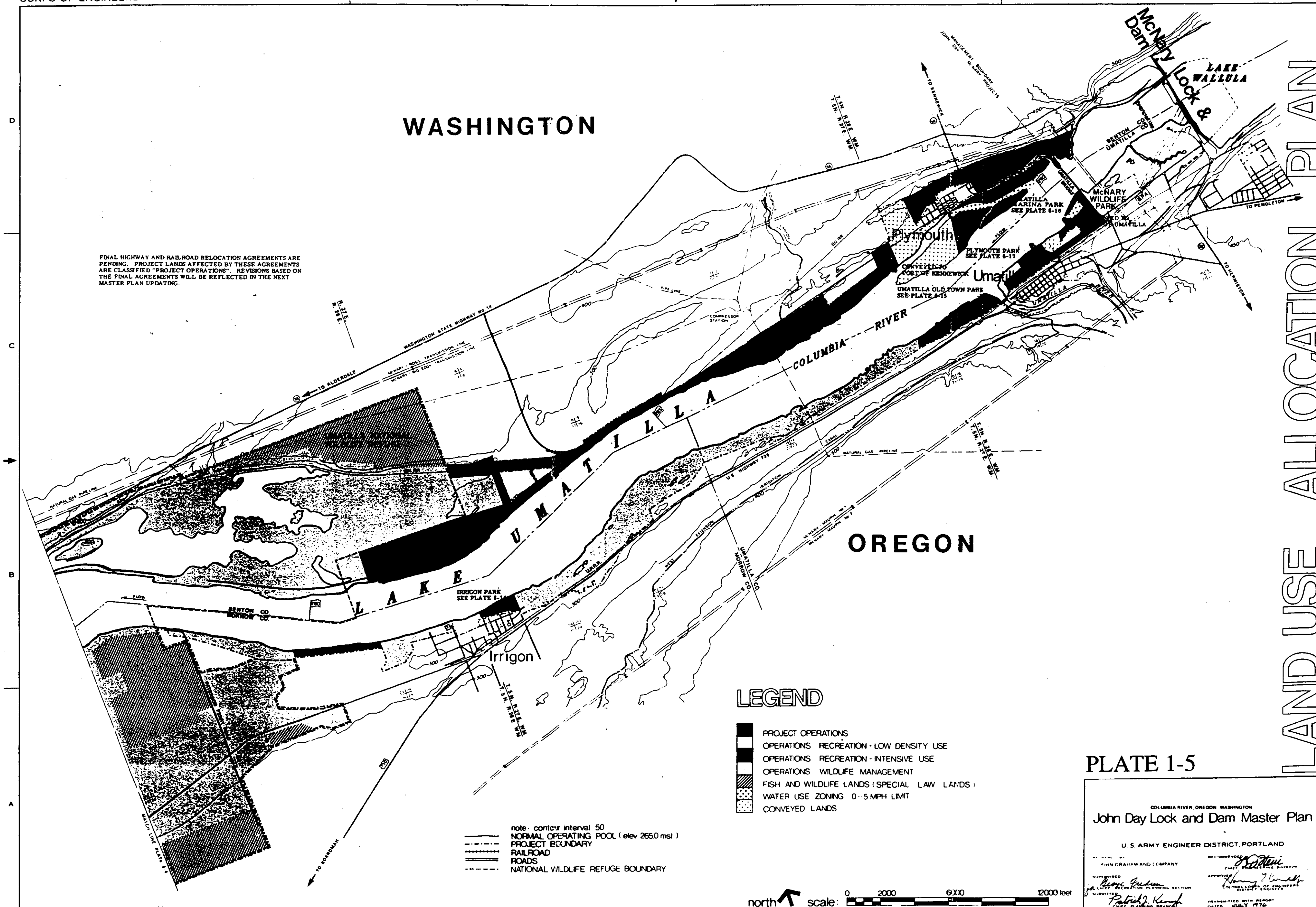

CORPS OF ENGINEERS
U.S. ARMY
LAND USE ALLOCATION PLAN
WASHINGTON
OREGON
LAKE UMATILLA
COLUMBIA RIVER
FINAL HIGHWAY AND RAILROAD RELOCATION AGREEMENTS ARE PENDING. PROJECT LANDS AFFECTED BY THESE AGREEMENTS ARE CLASSIFIED "PROJECT OPERATIONS". REVISIONS BASED ON THE FINAL AGREEMENTS WILL BE REFLECTED IN THE NEXT MASTER PLAN UPDATING.
ALDERDALE PARK SEE PLATE 6-20
QUESNEL PARK SEE PLATE 6-12
CONVEYED TO PORT OF ARLINGTON
Heppner Junction
WILLOW COVE
KLICKITAT CO.
GILLIAM CO.
MORROW CO.
INTERSTATE HIGHWAY 80N
TO BOARDMAN
FLOW
T.4N. R.21E. W.M.
T.4N. R.22E. W.M.
T.4N. R.23E. W.M.
T.3N. R.21E. W.M.
T.3N. R.22E. W.M.
T.3N. R.23E. W.M.
MATCH LINE PLATE 6-2
MATCH LINE PLATE 6-4
LEGEND
PROJECT OPERATIONS
OPERATIONS: RECREATION - LOW DENSITY USE
OPERATIONS: NATURAL AREA
OPERATIONS: WILDLIFE MANAGEMENT
WATER USE ZONING: 0-5 MPH LIMIT
CONVEYED LANDS
note: contour interval 50
NORMAL OPERATING POOL (elev. 265.0 msl)
PROJECT BOUNDARY
RAILROAD
ROADS
north
scale: 0 2000 6000 12000 feet
PLATE 1-3
COLUMBIA RIVER OREGON WASHINGTON
John Day Lock and Dam Master Plan
U.S. ARMY ENGINEER DISTRICT, PORTLAND
JOHN GRAHAM AND COMPANY
DATED: JULY 1976
10 20-2/6


LAND USE ALLOCATION PLAN
WASHINGTON
OREGON
Paterson
PATERSON ACCESS SEE PLATE 6-18
TO PLYMOUTH
WASHINGTON STATE HIGHWAY NO 14
BLALOCK ISLANDS
BENTON CO. MORROW CO.
KLICKITAT CO. BENTON CO.
LAKE UMATILLA
COLUMBIA RIVER
CROW BUTTE PARK SEE PLATE 6-19
BOARDMAN PARK SEE PLATE 6-13
CONVEYED TO PORT OF MORROW
Boardman
Boardman Space Age Industrial Park
TO HEPPNER JUNCTION
AIRPORT ROAD INTERCHANGE
TO PENDLETON
INTERSTATE HIGHWAY 80N
BOARDMAN JUNCTION
TO IRRIGON
FINAL HIGHWAY AND RAILROAD RELOCATION AGREEMENTS ARE PENDING. PROJECT LANDS AFFECTED BY THESE AGREEMENTS ARE CLASSIFIED "PROJECT OPERATIONS". REVISIONS BASED ON THE FINAL AGREEMENTS WILL BE REFLECTED IN THE NEXT MASTER PLAN UPDATING
NATURAL GAS PIPELINE
LEGEND
PROJECT OPERATIONS
OPERATIONS RECREATION - LOW DENSITY USE
OPERATIONS RECREATION - INTENSIVE USE
OPERATIONS WILDLIFE MANAGEMENT
FISH AND WILDLIFE LANDS (SPECIAL LAW LANDS)
WATER USE ZONING 0 5 MPH LIMIT
CONVEYED LANDS
note contour interval 50
NORMAL OPERATING POOL (elev 265.0 msl)
PROJECT BOUNDARY
RAILROAD
ROADS
NATIONAL WILDLIFE REFUGE BOUNDARY
north
scale: 0 2000 6000 12000 feet
PLATE 1-4
COLUMBIA RIVER OREGON WASHINGTON
John Day Lock and Dam Master Plan
U. S ARMY ENGINEER DISTRICT PORTLAND
PREPARED BY JOHN GRAHAM AND COMPANY
SUPERVISED CHIEF RECREATION PLANNING SECTION
SUBMITTED CHIEF PLANNING BRANCH
RECOMMENDED CHIEF ENGINEERING DIVISION
APPROVED COLONEL CORPS OF ENGINEERS DISTRICT ENGINEER
TRANSMITTED WITH REPORT DATED JULY 1976

CORPS OF ENGINEERS U. S. ARMY



JD 20-2/8